Long-Term Monitoring of Stream Habitat on the Pedlar Ranger District, George Washington & Jefferson National Forest, Virginia 1989-2015

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Introduction

The George Washington National Forest (GWNF) began a stream habitat inventory and monitoring program in the late 1980's. Inventories completed in 1989 were intended to inform the development of desired future conditions (DFC) for Forest Plan revisions. Inventories completed in 1995 assessed stream habitat conditions relative to the DFCs established in the 1993 GWNF Forest Plan. Specifically, a DFC for pool surface area of 35-65% of total stream area, and 125-300 pieces of large wood per mile in cold water streams (USDA 1993). The 2014 Revised GWNF Forest Plan, which guides current management, does not include DFCs, but instead has an objective for large wood of 200 pieces per mile (USDA 2014). A target for pool surface are is no longer used in the current Forest Plan, however we will refer to it in this report as a basis for comparison between years.

The GWNF partnered with the Forest Service Southern Research Station Center for Aquatic Technology Transfers (CATT) to complete baseline stream habitat inventories on 60 streams on the Pedlar Ranger District in 1989 and 1995 (Underwood et al. 1995). Between 1995 and 2005 timber management occurred in the watersheds of several streams and many were also impacted by severe flooding in 1995, 1996, and 2004, initiating a second round of habitat inventories by CATT in 2005 for 15 of the previously inventoried streams (Kyger et al.2005). By 2015, most of the Pedlar Ranger District had been infested by hemlock wooly adelgid, an invasive insect that rapidly kills hemlocks, and in many areas hemlocks had begun to break off or topple over into stream channels, prompting a 3rd round of habitat inventories on the 15 streams we visited in 2005. The CATT supplied a team of six field technicians to complete the inventories between June 8th and August 20th, 2015. This report summarizes results from the 2015 inventories and examines for differences in stream habitat among the three rounds of inventories.

Methods

The Center for Aquatic Technology Transfer (CATT), Southern Research Station, inventoried stream habitat in selected sections of 15 streams within the Pedlar Ranger District, GWNF, Virginia, in 1989 (2 streams on July 21) and 1995 (13 streams May 22 – August 17), 2005 (May 31 – July 5), and 2015 (June 8 – August 20) (Figures 1-10). We employed the basinwide visual estimation technique (BVET) (Dolloff et. al 1993) to inventory stream sections selected by Mark Hudy or Dawn Kirk (George Washington and Jefferson National Forest, GWJNF, Fish Biologist). For comparisons among years, we attempted to inventory as closely as possible the same section inventoried in previous years, and overlap among years was sufficient for comparison the majority of the time (Figures 2-10).

Inventory Reach Selection

Mark Hudy (GWJNF Forest Fish Biologist, retired) selected streams for inventory in 1989 and 1995. The streams were selected with the intent of providing a nearly comprehensive inventory of Pedlar District streams. Inventories began at the Forest boundary or at a major stream confluence and ended where the inventory team determined there was no upstream fish habitat (typically dry, or wetted width < 1 m for at least 0.5 km), or where an impassable waterfall or cascade was encountered. Dawn Kirk (GWJNF Forest Fish Biologist) selected a subset of the original streams for re-inventory in 2005. Inventory teams used maps and notes from the original inventories to try to match the stream reaches inventoried in 1989 – 1995. Our 2015 inventory teams used maps, notes, and GPS coordinates to find the stream reaches inventoried in 2005.

Comparing stream habitat attributes among the three time periods requires the BVET inventory to occur on the same section of stream (i.e. reach). There were two discrepancies; 1) the 1995 Maple Creek section is different from the 2005 and 2015 section and is excluded from between-year comparisons, and 2) the Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed, thus being too short (0.3 km) for comparison with the 1 km inventories in 1989 and 2015 (Figure 2 and Table 1).

The length of the BVET inventory is largely predetermined by the distance between the USFS property boundary or confluence (start location) to the headwater, USFS property boundary, confluence, or impassable waterfall/cascade (end location) (Figures 2-10). Inventory lengths were trimmed based on the distance difference between the inventory start/end location and fixed feature locations such as tributaries, fords, or culverts whenever possible (Tables 1 and 2). These 'comparison lengths' (i.e. inventory length adjusted to be as similar as possible between years for data comparison) ranged from 0.6 km to 5.4 km for the 15 streams (Table 1). Comparison lengths may still vary somewhat between years by stream due to hip-chain measurement variability. This variability was typically ≤0.3 km with one exception; Coxs Creek 1995 inventory length was 0.4 km longer than the 2005 and 2015 inventories despite all three inventories starting at the USFS boundary and ending at or near (+54 m) a tributary confluence (Tables 1 and 2). GPS coordinates for the start and end locations of the inventories are available in Table 3.

Habitat Inventory

We used a two-stage visual estimation technique to quantify stream habitat (Dolloff et al. 1993). During the first stage, habitat was stratified into similar groups based on naturally occurring habitat units including pools (areas in the stream with concave bottom profile, gradient equal to zero, greater than

average depth, and smooth water surface), and riffles (areas in the stream with convex bottom profile, greater than average gradient, less than average depth, and turbulent water surface). Glides (areas in the stream similar to pools, but with average depth and flat bottom profile) were identified during the inventory, but were grouped with pools for data analysis. Runs (areas in the stream similar to riffles but with average depth, less turbulent flow, and flat bottom profile) and cascades (areas in the stream with > 12% gradient, high velocity, and exposed bedrock or boulders) were grouped with riffles for data analysis.

Habitat in each section of stream was classified and inventoried by a 2 person crew. One crew member identified each habitat unit by type (as described above), estimated average wetted width, average and maximum depth, riffle crest depth (RCD), substrate composition, and percent fines. The length of each habitat unit was measured with a hip chain. Average wetted width was visually estimated. Average and maximum depth of each habitat unit were estimated by taking depth measurements at various places across the channel profile with a graduated staff marked in 5 cm increments. The RCD was estimated by measuring water depth at the deepest point in the hydraulic control between riffles and pools. The RCD was subtracted from average pool depth to obtain an estimate of residual pool depth potentially occurring during low flow conditions. Substrates were assigned to one of nine size classes (Appendix A). Dominant substrate (covered greatest amount of surface area in habitat unit) and subdominant substrate (covered 2nd greatest amount of surface area in habitat unit) were visually estimated. Percent fines is the percent surface area of the stream bed consisting of sand, silt, or clay substrate particles (particles < 2 mm diameter). In addition, several attributes of road-stream crossings (location, type, size, etc.) were recorded, where encountered.

The second crew member classified and inventoried large wood (LW) of all tree species (including hemlock) within the bankfull channel and recorded all data. Large wood was assigned to one of four size classes (Appendix A). All wood less than 1.0 m long and less than 10 cm in diameter were omitted from the inventory. In addition, a separate count of hemlock large wood (all size classes combined) was recorded when large wood could be identified as hemlock.

The first unit of each habitat type selected for intensive (second stage) sampling (e.g. accurate measurement of wetted width) was determined randomly. Additional units were selected systematically (every 10th habitat unit type for streams >1000 m and every 5th habitat unit type for streams <500 m). The wetted width of each systematically selected habitat unit was measured with a meter tape across at least three transects and averaged. At each of the systematically selected riffles we also recorded hemlock abundance and condition based on observations made in between second stage fast-water units (Appendix A). Hemlock abundance is an estimate of the total number of standing hemlock trees in the riparian zone. Hemlock condition is a visual estimate of the condition (healthy/light wooly adelgid

infestation, infested, or dead) of standing hemlock trees in the riparian zone. Lastly, water temperature was measured with a thermometer in flowing water, out of direct sunlight.

Attributes not collected in 1989/1995 were RCD (thus, residual pool depth cannot be calculated), substrate (both dominant and subdominant), and percent fines. In 2015 the following additional attributes were added; hemlock large wood count, hemlock condition, and hemlock abundance. All estimates, measurements, and confidence intervals from the BVET inventories were summarized using Microsoft Excel and formulas found in Dolloff et al. (1993). See Appendix A for detailed field methods and Appendix B for BVET summary tables for each stream.

Results

Water Depth

For all inventories (1995-2015), maximum depths for pools (includes glides) averaged between 26 cm and 64 cm (Table 4). Maximum pool depths increased on average with each successive inventory in four streams; Dancing Creek, Enchanted Creek, King Creek, and Loves Run (Figure 11). There was no consistent increase or decrease in maximum pool depth averages for Coxs Creek, North Fork Bennetts Run, and Pedlar Gap Run (Figure 11). There were six streams with a decrease in mean maximum pool depth between 1995 and 2015; exceptions were Maple Creek and Rocky Branch, which can only be assessed between two time periods, saw a decrease and very slight increase, respectively (Figure 11). See Appendix C (Figure C1) for 2015 depths displayed longitudinally.

Mean residual pool depth ranged from 8 cm to 28 cm in 2005 and 2015 inventories (Figure 12 and Table 4). Between 2005 and 2015, mean residual pool depth increased in seven streams (Cox Creek, Dancing Creek, Enchanted Creek, Greasy Spring Branch, King Creek, Love Lady Creek, and Loves Run) and decreased in seven streams (Belle Cove Branch, Big Marys Creek, Kennedy Creek, Little Cove Creek, Maple Creek, North Fork Bennetts Run, and Pedlar Gap Run). The largest decrease in mean residual pool depth was in Maple Creek, from 28 cm in 2005 to 8 cm in 2015 (Figure 12 and Table 4).

Pool to Riffle Ratio

The GWJNF's DFC of 35-65% pool habitat, was met by only one stream in 2015, Love Lady Creek (41% pool area) (Figure 13 and Table 5). All the other streams are below this desired condition. Five streams (Coxs Creek, Dancing Creek, Enchanted Creek, Maple Creek, and North Fork Bennetts Run) met the desired condition in 1995, but have dropped below 35% pool habitat in 2005 and remained below the threshold in 2015 (Figure 13). Nine streams did not meet the desired pool habitat condition in any year (Figure 13).

The only significant increase in pool habitat area was in Love Lady Creek between 2005 and 2015 (Figure 14). There are numerous significant decreases in pool habitat area between 1989/1995 – 2005 and 2005 – 2015 (Figure 14).

Substrate and Percent Fines

A mix of fine and coarse substrates dominated slow water habitat units in most streams across all years (Figure 15, Tables 6 and 7). Maple Creek is the exception with 100% sand in 2005 and a mix of sand, cobble, and bedrock in 2015 (Figure 15 and Table 6). Enchanted Creek and Pedlar Gap Run had large increases in sand (+41% and +28% respectively) between 2005 and 2015 (Figure 15 and Table 6). Conversely, Greasy Spring Branch, King Creek, and Maple Creek experienced large declines in sand (-38%, -31%, and -48% respectively) (Figure 15 and Table 6). A large increase in small gravel occurred in Belle Cove Branch (+23%), whereas a decrease occurred in Big Marys Creek (-61%) and Love Lady Creek (-25%) (Figure 15 and Table 6).

Coarse substrates dominated fast water habitat units in most streams across all years (Figure 16, Tables 8 and 9). Maple Creek is the exception with 100% sand in 2005 and a mix of coarse substrates in 2015 (Table 8). While most streams had some substrate composition change between 2005 and 2015, the change was predominantly a shifting of proportions of coarse substrate (Figure 16). Contrary to this is Maple Creek, which had a complete shift from fine sediments to coarse substrates between years. See Appendix C (Figures C2 and C3) for 2015 substrate displayed longitudinally.

Percent fines in pools in Enchanted Creek and Little Cove Creek increased above the 35% fines threshold that can cause detrimental effects to stream fishes (Everest et al. 1987) (Figure 17 and Table 10). Percent fines in pools remained above 35% in 2005 and 2015 in Maple Creek, North Fork Bennetts, and Pedlar Gap Run (Figure 17 and Table 10). Percent fines in pools in Greasy Spring Branch went from >35% in 2005 to <35% in 2015 (Figure 17 and Table 10). Percent fines in riffles are below the 35% threshold in all the inventoried streams in 2015; and Maple Creek is the only stream above the threshold in 2005 (Figure 18 and Table 10). See Appendix C (Figure C4) for 2015 percent fines displayed longitudinally.

Large Wood

The total pieces of large wood per kilometer (LW/km) increased between 2005 and 2015 in all 14 streams inventoried (Figure 19 and Table 11). The most notable increases between 2005 and 2015 occurred in Big Marys Creek (+129), Coxs Creek (+55), Enchanted Creek (+68), Greasy Spring Branch (+73), Little Cove Creek (+52), and Loves Run (+99) (Figure 19 and Table 11). The increase in LW/km seen between 2005 and 2015 is largely the result of increased quantities of the smallest large wood size

class (LW1 = 1-5 m length, 10-55 cm diameter) (Figure 19 and Table 11). For all streams, the majority of large wood was small diameter LW1 and LW3 size classes (10-55 cm diameter) (Figure 19). While there is consistent LW/km increases between 2005 and 2015, there were large declines in LW/km between 1995 and 2005 in Belle Cove Branch and North Fork Bennetts Run (Figure 19 and Table 11). The quantity of LW/km varied between streams; in 2015 there were six streams with about 50 pieces of LW/km (Belle Cove Branch, Kennedy Creek, King Creek, Love Lady Creek, Maple Creek, and Pedlar Gap Run), four streams with about 100 pieces of LW/km (Coxs Creek, Dancing Creek, Little Cove Creek, and North Fork Bennetts Run), and four streams with >150 pieces of LW/km (Big Marys Creek, Enchanted Creek, Greasy Spring Branch, and Loves Run) (Figure 19), which meets the GWJNF target of 124 LW/km (200 pieces per mile) to maintain habitat diversity for aquatic species (USDA 2004 and 2014).

The separate count of hemlock large wood resulted in 13 streams having some large wood in the stream identifiable as hemlock (Table 12). Streams with >50 pieces of hemlock LW/km were Big Marys Creek, Enchanted Creek, Greasy Spring Branch, and North Fork Bennetts Run (Table 11). See Appendix C (Figure C5) for 2015 total large wood per habitat unit displayed longitudinally and Appendix D for total large wood counts displayed longitudinally for each stream by year.

Hemlock Abundance and Condition

Hemlocks were present in the riparian area of 13 streams in varying degrees of abundance (Figure 20). Little Cove Creek and Rocky Branch (though the Rocky Branch inventory was only 0.3 km) were the only streams with no hemlocks recorded (Figure 20). Three streams had high (>50) hemlock abundance for a portion of the inventory; Big Marys Creek, Dancing Creek, and Enchanted Creek (Figure 20).

Riparian hemlock condition varied longitudinally for the majority of streams having hemlock wooly adelgid infestations (Figure 20). The only stream with a hemlock condition of 'healthy/light infestation' was Loves Run for the short segment of the inventory with low (1-10) hemlock abundance (Figure 20). There are five streams having 'dead' hemlock condition for the majority of the inventory length; Coxs Creek, Dancing Creek, Greasy Spring Branch, King Creek, and North Fork Bennetts Run (Figure 20). There are five other streams having 'dead' hemlock condition present in a portion of the inventory length; Belle Cove Branch, Big Marys Creek, Kennedy Creek, Love Lady Creek, and Pedlar Gap Run (Figure 20). When comparing hemlock abundance and condition to total LW or Hemlock LW loading there was no discernable correlation. (Figure 21).

Discussion

Stream inventories were initiated on the GWJNF over 20 years ago to establish a baseline from which to monitor for future changes in stream habitat. Over half of the streams in the initial round of inventories fell below the desired condition for pool area and nearly three-quarters were below the desired condition for large wood. These habitat characteristics are a typical legacy of wholesale logging that was completed over much of the district in the late 19th and early 20th centuries. Where large scale stream habitat improvement projects are impractical, remediation tactics focus on reducing sediment and increasing large wood delivery to streams through improved watershed and riparian management. Increased large wood and reduced fine sediments should improve channel complexity and roughness and favor pool development over time, but this process can be slow, uneven, and confounded by disturbances that impact stream channels or riparian development.

Following large floods in 2005, only one stream met the minimum for pool area and another met the minimum for large wood. By 2015, one stream met the desired conditions for pool area (though not the same stream as in 2005), and a handful of streams met the desired condition for large wood, though all streams had increases in large wood likely related to the dead and dying hemlocks along most streams. Without direct manipulation habitats will continue to be shaped by a combination of land management actions and natural disturbances. In the short-term the most obvious changes in stream habitat will be related to the continued addition of large wood from adelgid infested riparian hemlock stands.

The relatively recent large-scale die off of hemlocks, though tragic, also presents an opportunity as the GWJNF continues to address the impacts on the Forest from historical land use. The riparian areas of the majority of inventoried streams contain hemlock trees infested with hemlock wooly adelgid. In many areas these hemlocks are shedding limbs and tops, while others are toppling entirely into the stream channel, providing a variety of large wood sizes. All the inventoried streams with hemlocks present in the riparian area had hemlock large wood in the channel and recruitment of hemlock large wood to the channel will continue until the hemlocks are gone. Hemlocks can also be deliberately felled into stream channels to strategically provide additional channel complexity in high-priority management areas. Of all the inventoried streams, only four had more than150 pieces per km and all were largely lacking in wood of the largest size class (LW4). One possibility for the increase in the small size LW1 in 2015 could be the shedding of branches from dead hemlocks.

Given the high number of dead or dying hemlocks, these streams are prime targets for large wood treatments, but how much wood is enough? The GWJNF Forest management plan specifies that approximately 124 LW/km (200 pieces per mile) is sufficient to maintain habitat diversity for aquatic species (USDA 2004 and 2014). National Forests in South Carolina and North Carolina specify a desired large wood condition of 322 and 161 LW/Km, respectively (USDA 1994 and 2004b). Researchers have

not found an upper limit to the amount of large wood that is beneficial to fish so most often the upper limit will be determined by social factors rather than fish habitat objectives (Richards and Hollingsworth 2000), particularly in areas managed for multiple uses.

The increased quantities of large wood seen during our 2015 inventories, versus 2005, should promote pool habitat creation and complexity. We expect this trend of increased large wood to continue due to increased recruitment of hemlock trees being killed by the hemlock wooly adelgid. As habitat complexity increases, the likelihood that large wood will remain in place rather than being flushed out during high flow events also increases, leading to development of a self-sustaining system. From 1995 to 2005, the loss of large wood in most streams likely caused the decline in pool habitat observed in all inventoried streams. There was a dramatic loss of large wood in Belle Cove Branch and North Fork Bennetts Run between these years. A pulse of large wood entered these two streams in June 1995 from landslides (resulting from a major flood) prior to the August 1995 BVET inventory. Over the next 10 years this wood was flushed out (potentially during another major flood event in January 1996). Other streams also experienced flooding (but not landslides) in 1995 and 1996 (Pedlar Gap Run), and 2004 (Big Marys Creek, Kennedy Creek, and Loves Run), but did not see pulses of large wood being deposited or flushed out the stream, suggested landslides caused the large wood contributions. From 2005 to 2015, the increase in large wood in all streams should promote pool habitat formation, though we are still observing pool habitat declines in most streams. It is possible that pool formation has yet to catch up to the large wood inputs or that total amount or sizes of large wood are not sufficient to promote pool formation.

Once the hemlocks are gone, future recruitment of large wood will depend on other woody species to replace eastern hemlock in near stream riparian areas. Ford et al. (2012) suggest these canopy genera in the southern Appalachians will be comprised of maple, birch, beech, and oak. However, when the understory shrub species rhododendron is present it exploits the increased light availability, its growth and dominance increase, and once established dense thickets can persist for many decades (Ford et al. 2012). Rhododendron's strong response suggests the long-term changes in forest community composition could be lacking a strong canopy component (Ford et al. 2012). Therefore, direct additions of large wood may be needed in the short term and silviculture prescriptions addressing the lack of recruitment may be needed to ensure continued delivery of adequate amounts of large wood in the future.

Several streams had high percentage of fine substrates, which could impact fish reproduction, particularly in salmonids such as Brook Trout (Everest et al. 1987). Fines can be reduced during flushing flows from storm events, and may be somewhat mitigated where large wood improves stream habitat though pool creation and habitat complexity. Newly formed plunge pools from large wood can help flush out fine sediments and expose additional patches of spawning gravel (Ryan et al. 2014, Faustini and Jones 2003, Thompson 1995).

Land management practices such as wholesale logging in the watershed in the early 1900's are still impacting the number and size of trees available, as well as sediment inputs. Efforts to reverse or mitigate habitat degradation effects have been ongoing for decades and will continue into the foreseeable future. In the long run, it will prove cost-effective to manage riparian areas to provide a source of large wood for natural recruitment. Clearly, decisions made by today's land managers will impact large wood recruitment and retention, and sediment transport and deposition, for decades to come. New challenges may present new opportunities and we encourage the GWJNF to continue their work to improve stream habitat.

Data Availability

Summer 2015 stream habitat data reside in a MS Access database, which is managed by the CATT, and a copy has been provided to Dawn Kirk, GWJNF Forest Fish Biologist. We will work with the GWJNF to develop custom queries and reports for the MS Access database, as needed.

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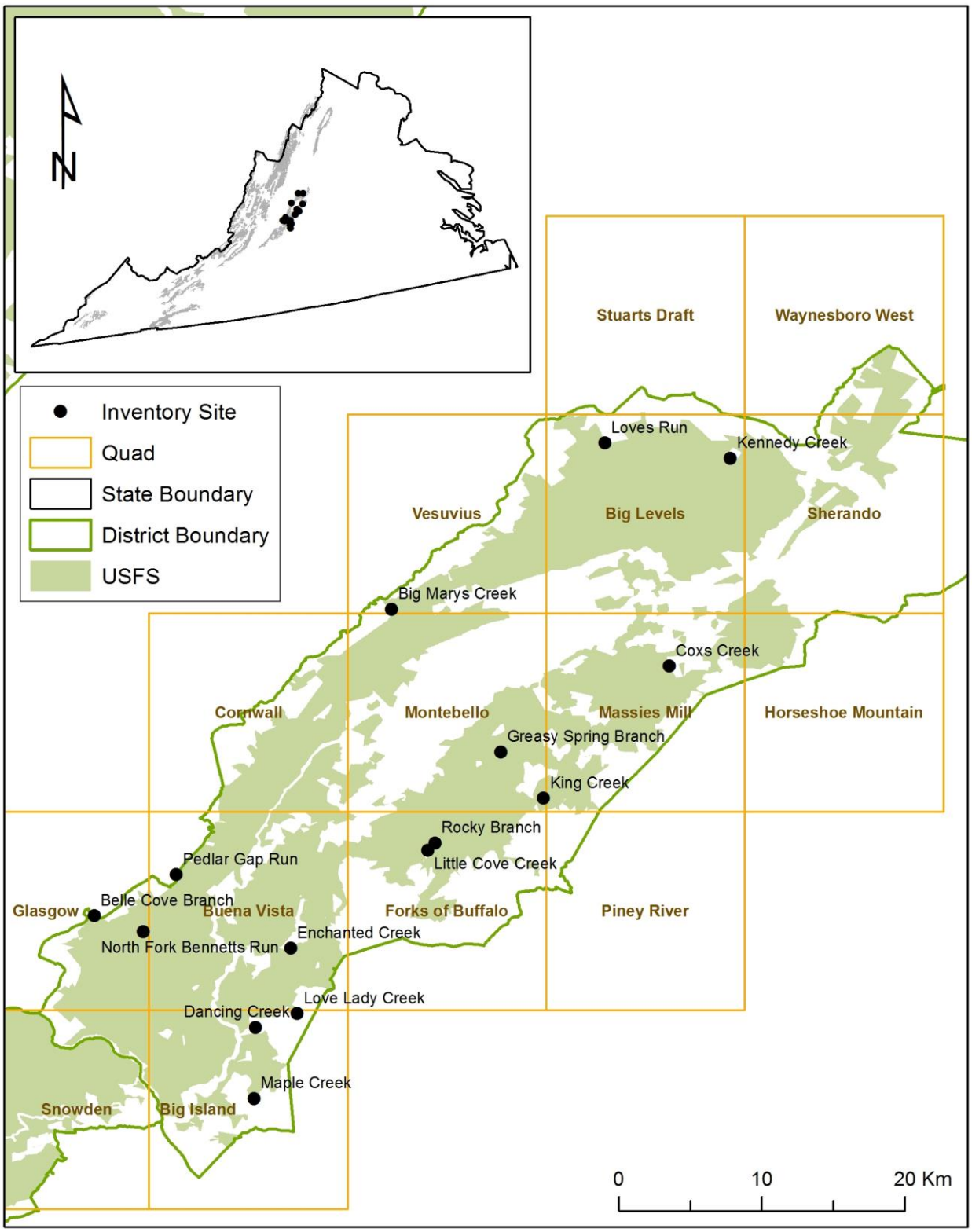

Figure 1. Streams visited on the Pedlar Ranger District in 1995, 2005, and 2015.

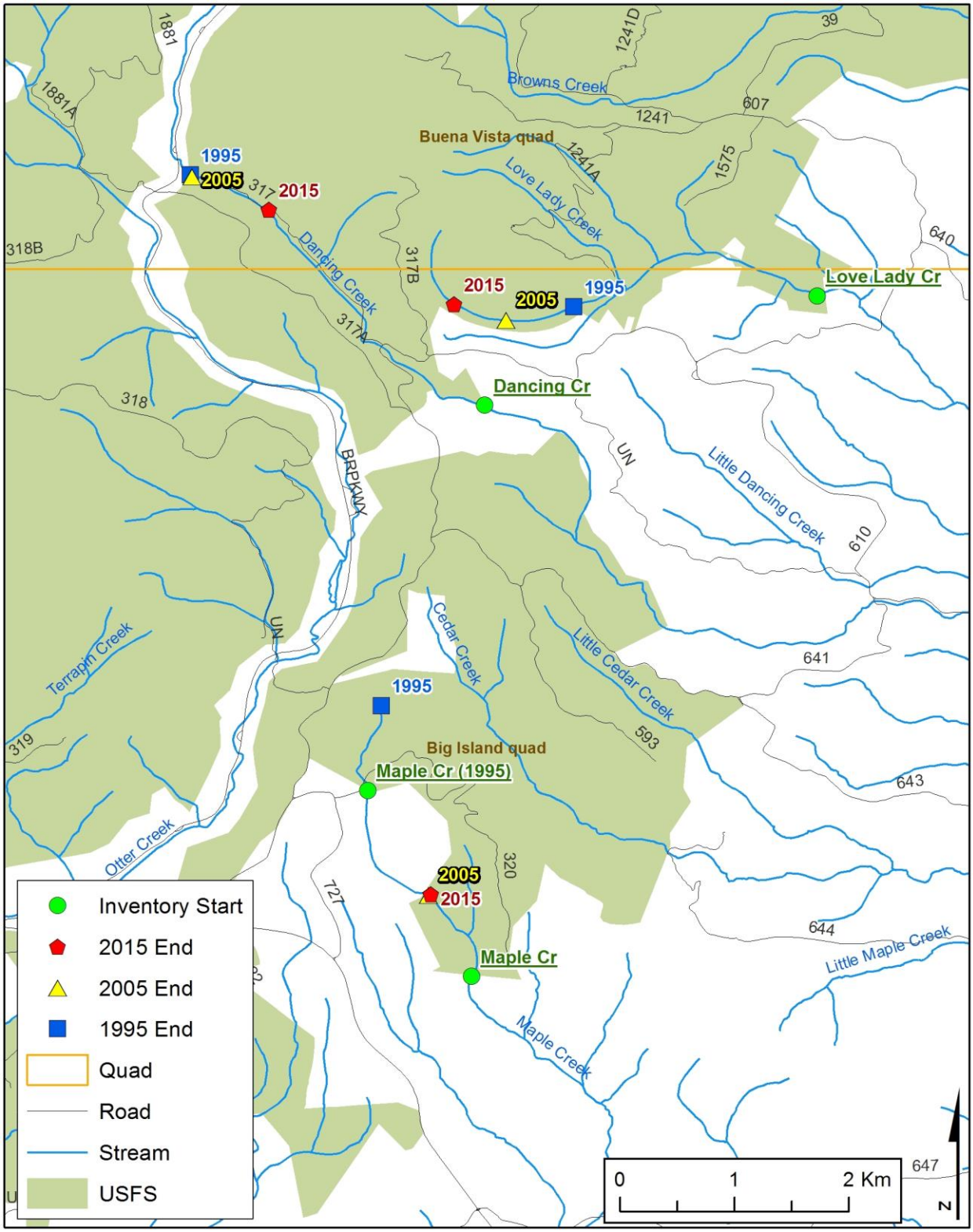

Figure 2. BVET inventory start and end location on Dancing Creek, Love Lady Creek, and Maple Creek; Big Island and Buena Vista quads.

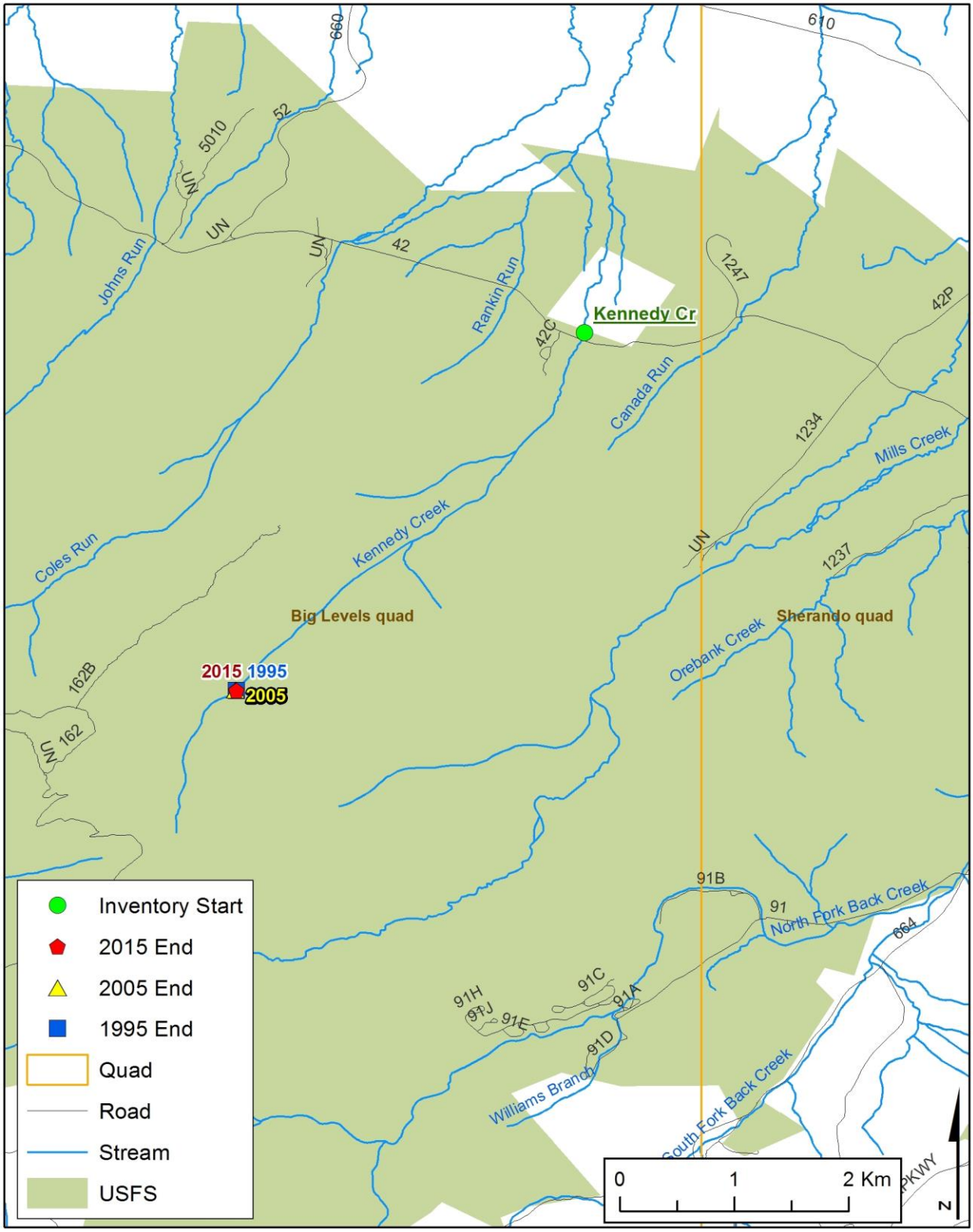

Figure 3. BVET inventory start and end location on Kennedy Creek; Big Levels quad.

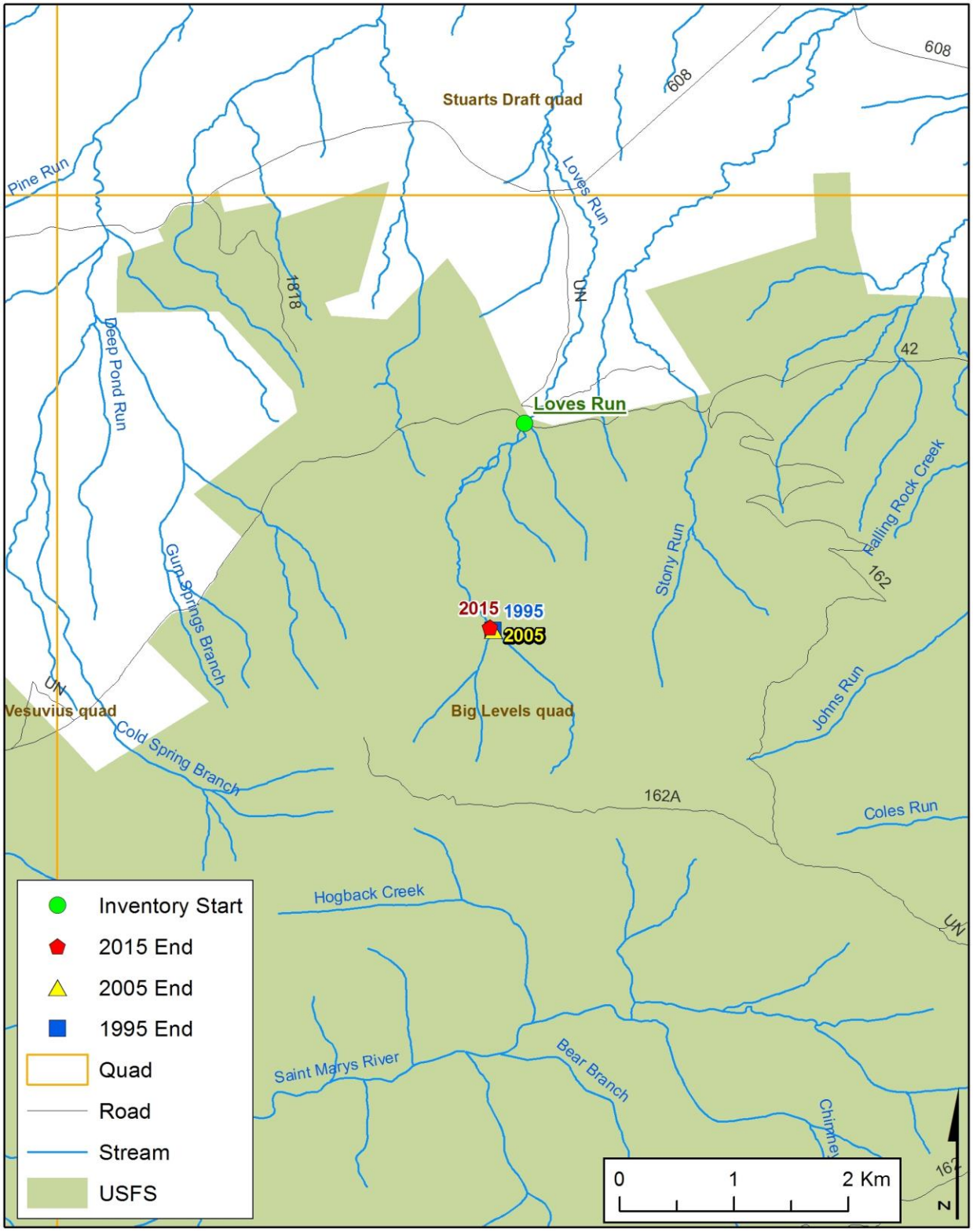

Figure 4. BVET inventory start and end location on Loves Run; Big Levels quad.

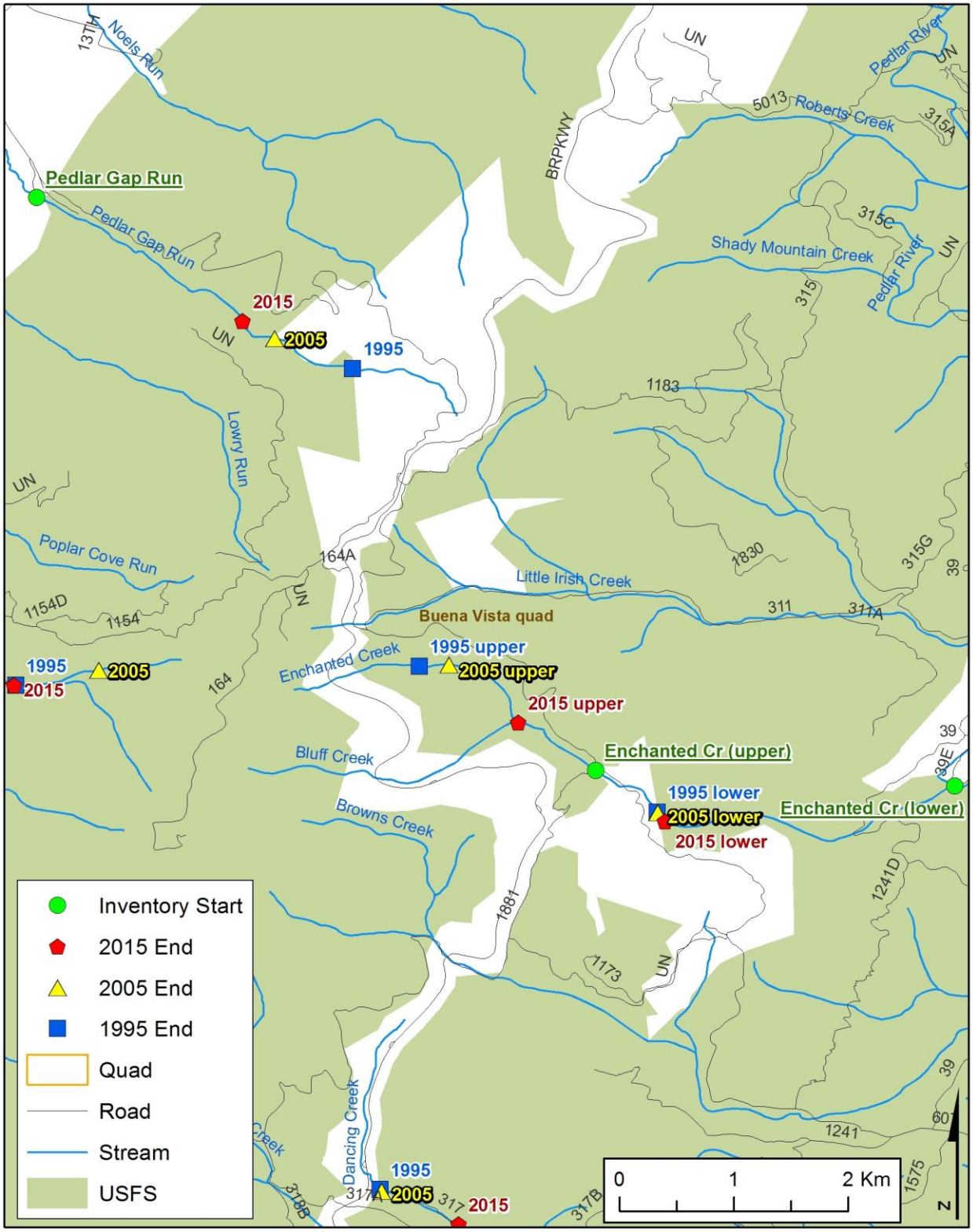

Figure 5. BVET inventory start and end locations on Enchanted Creek (lower and upper sections) and Pedlar Gap Run; Buena Vista quad.

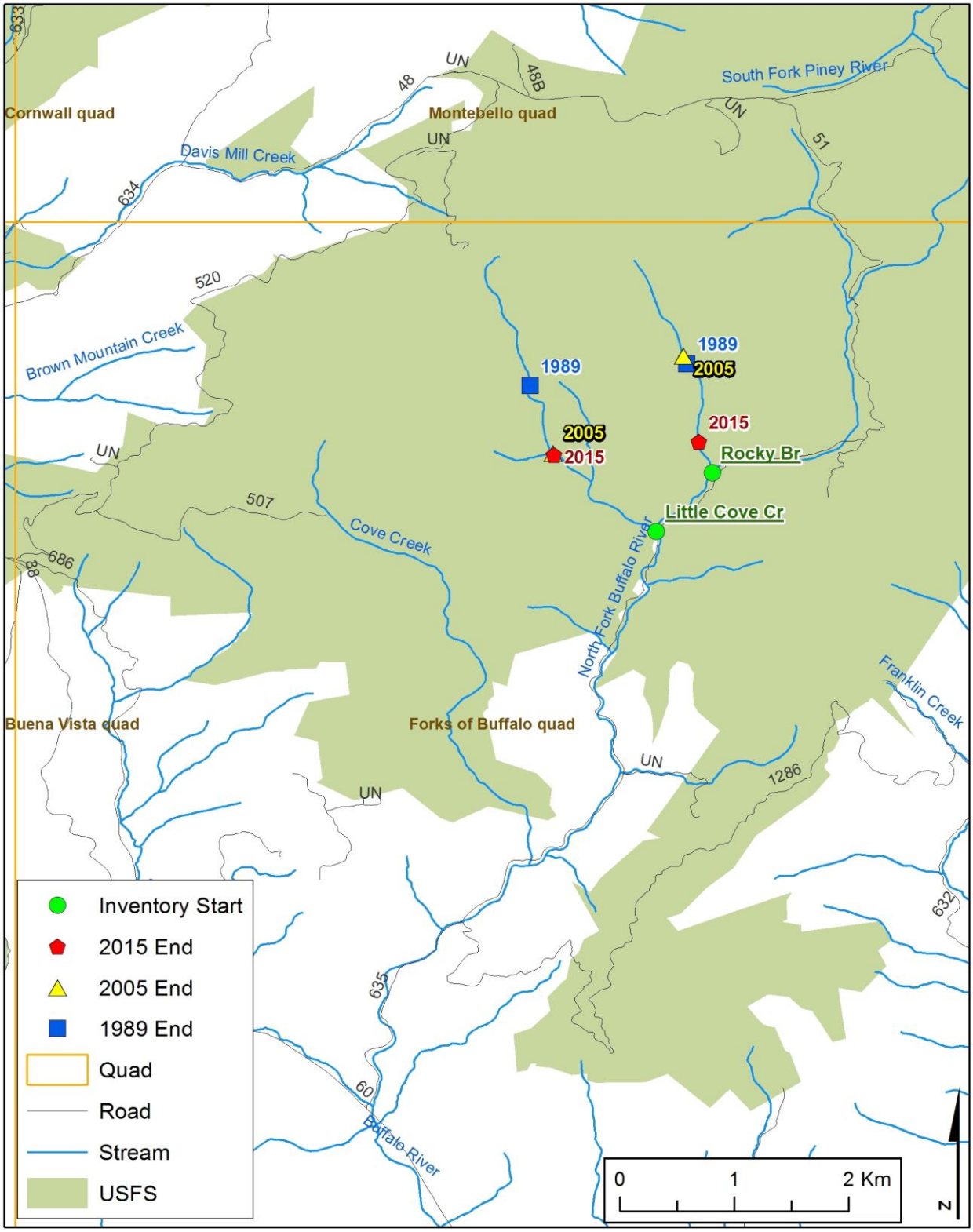

Figure 6. BVET inventory start and end locations on Little Cove Creek and Rocky Branch; Forks of Buffalo quad.

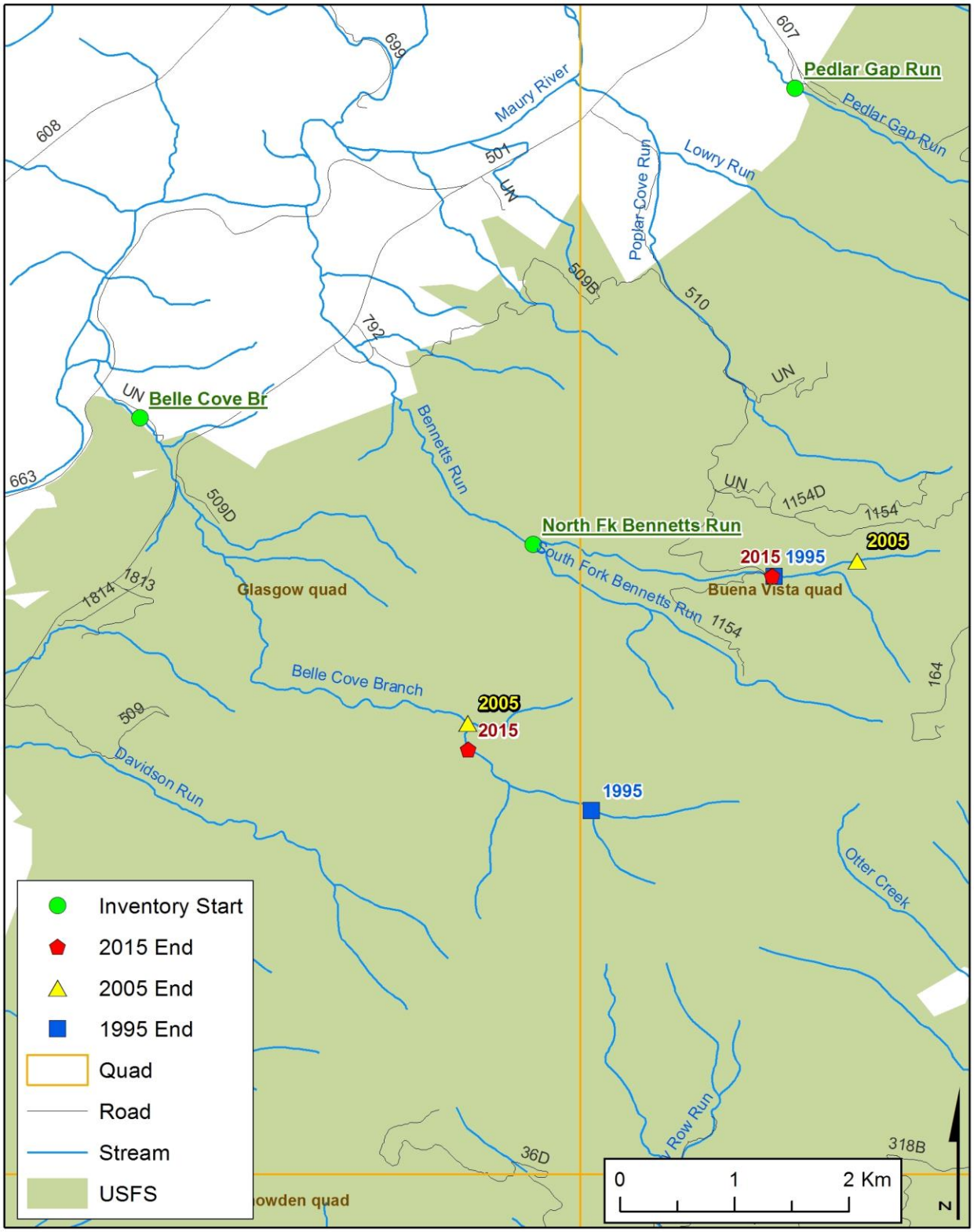

Figure 7. BVET inventory start and end locations on Belle Cove Branch and North Fork Bennetts Run; Glasgow and Buena Vista quads.

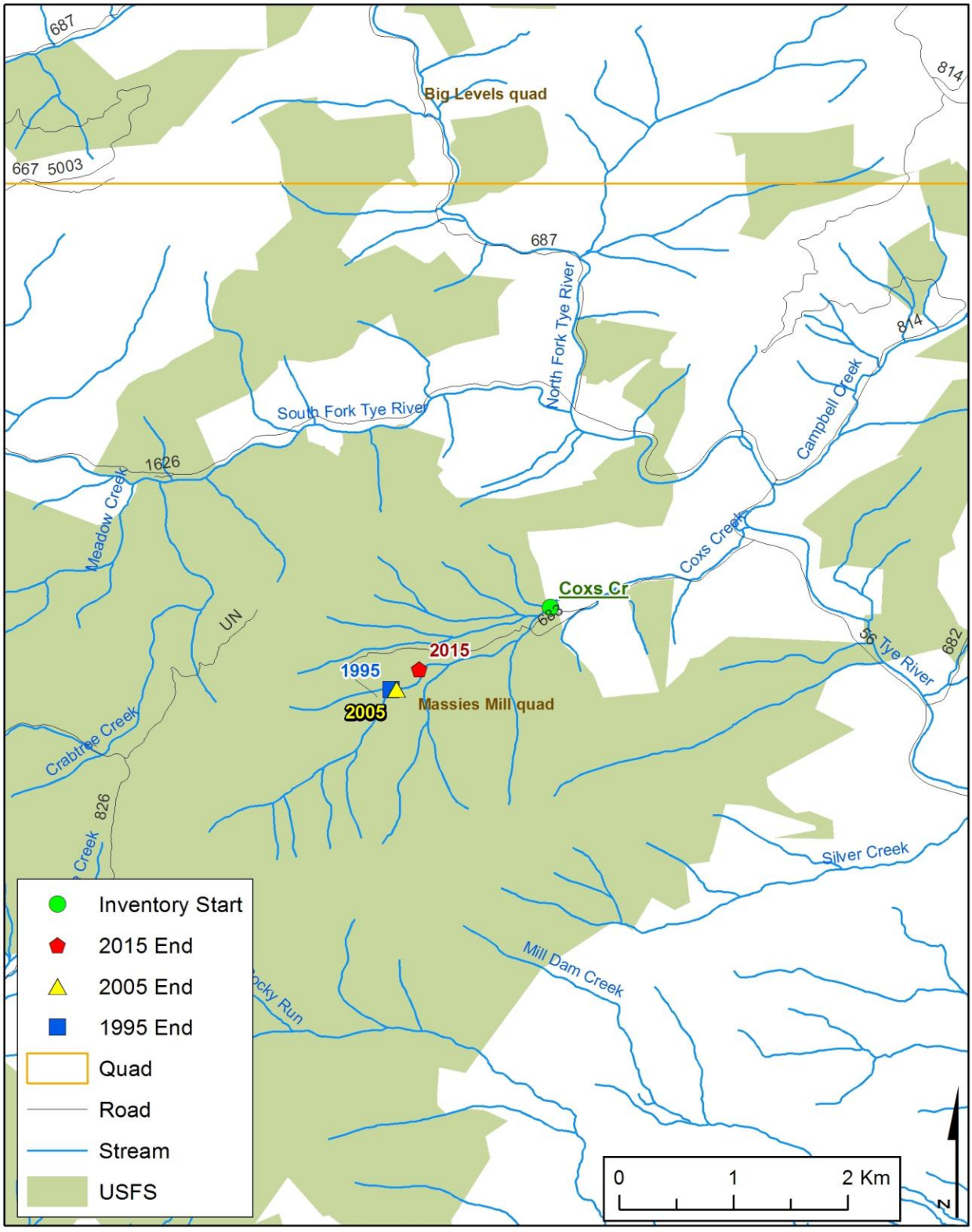

Figure 8. BVET inventory start and end locations on Coxs Creek; Massies Mill quad.

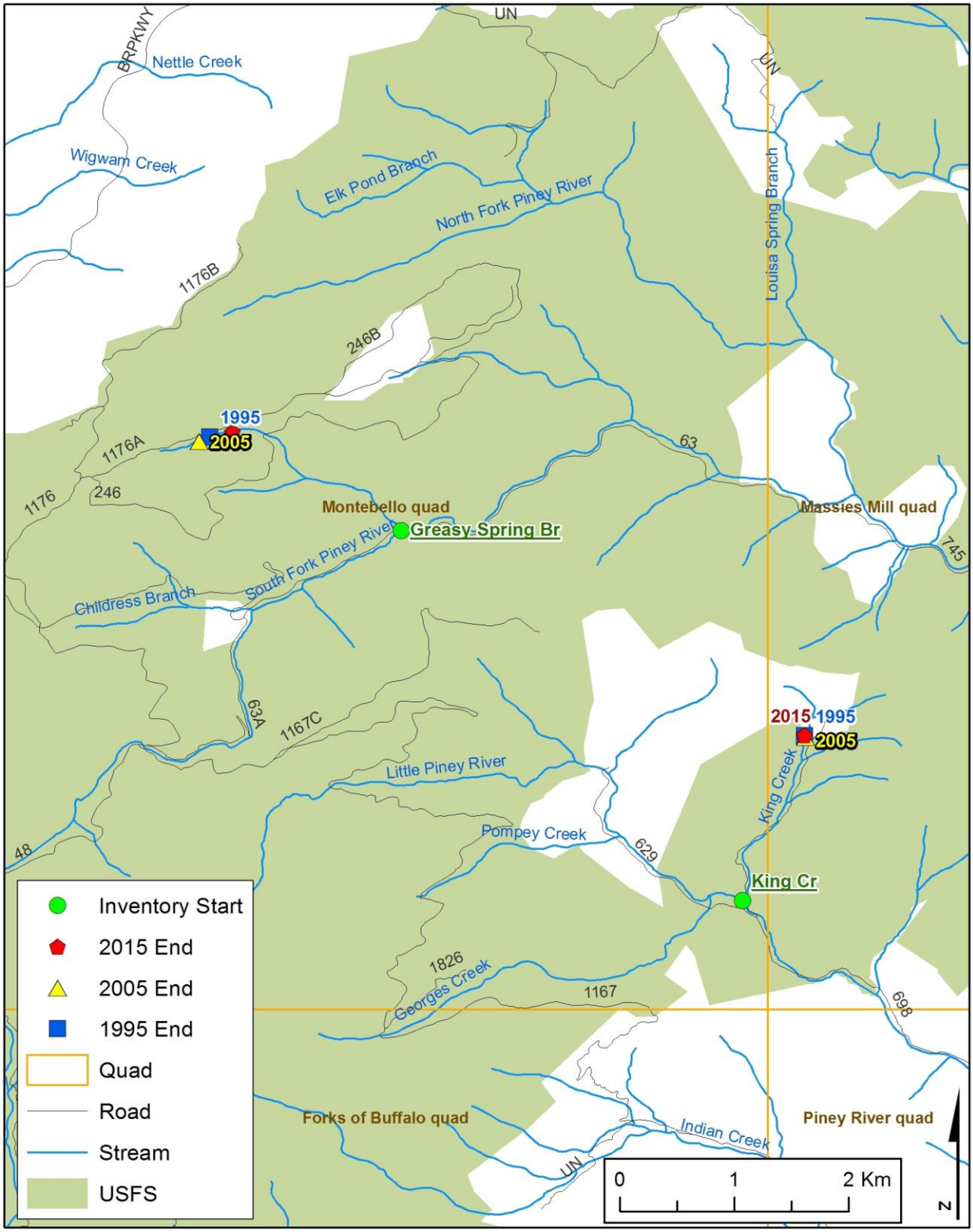

Figure 9. BVET inventory start and end locations on King Creek and Greasy Spring Branch; Montebello and Massies Mill quads.

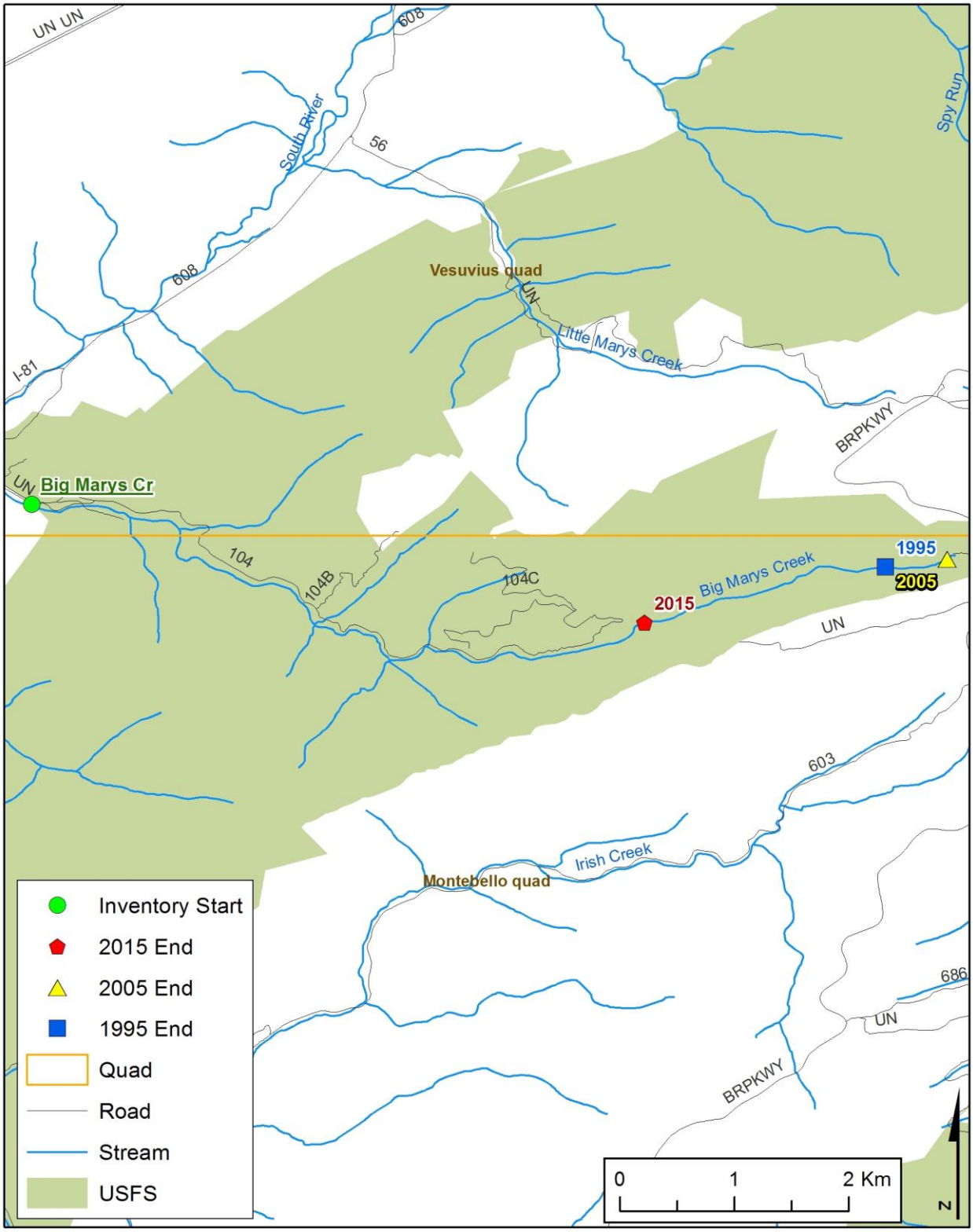

Figure 10. BVET inventory start and end locations on Big Marys Creek; Vesuvius and Montebello quads.

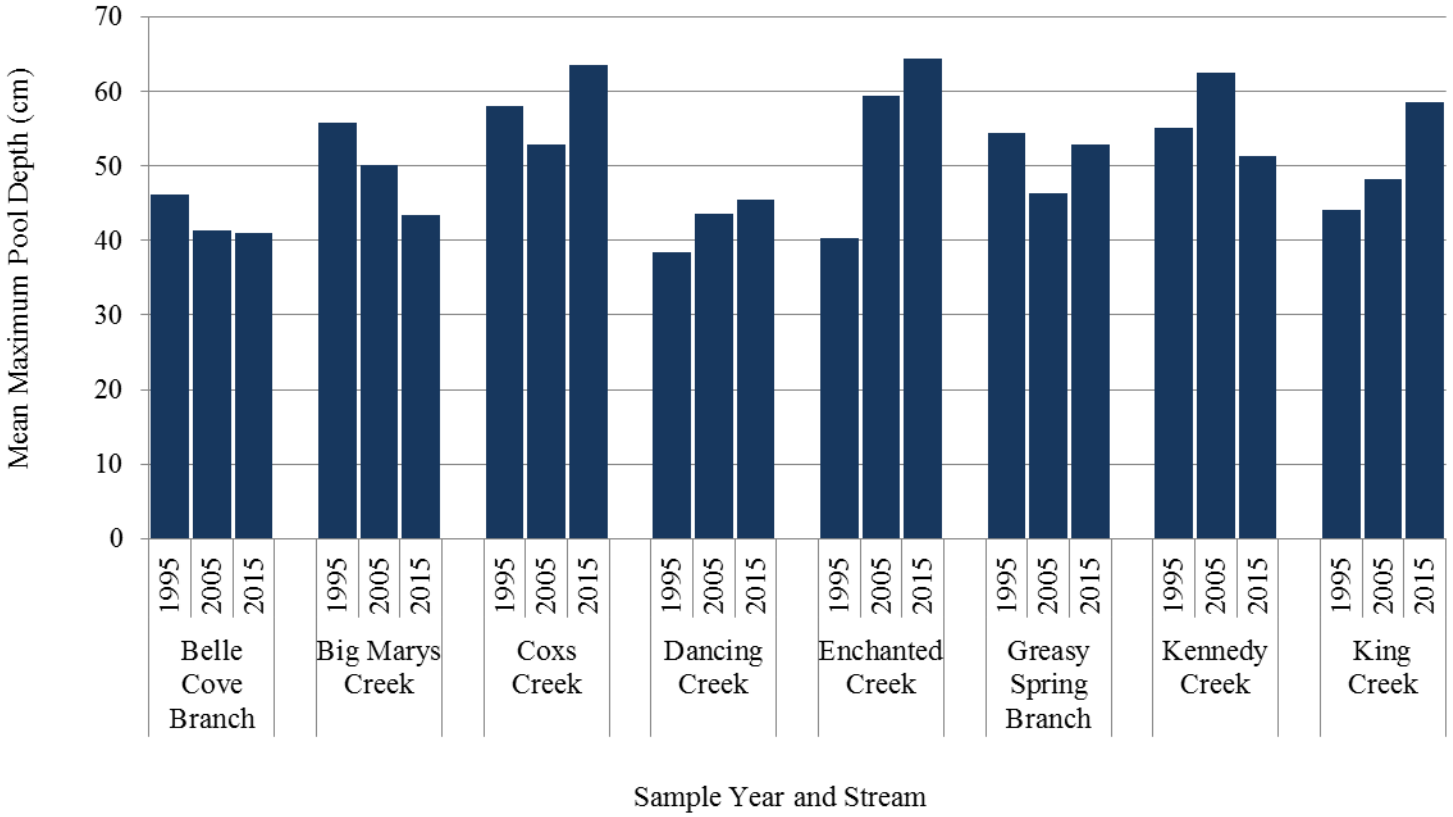

Figure 11. Mean maximum pool depth (includes glide).

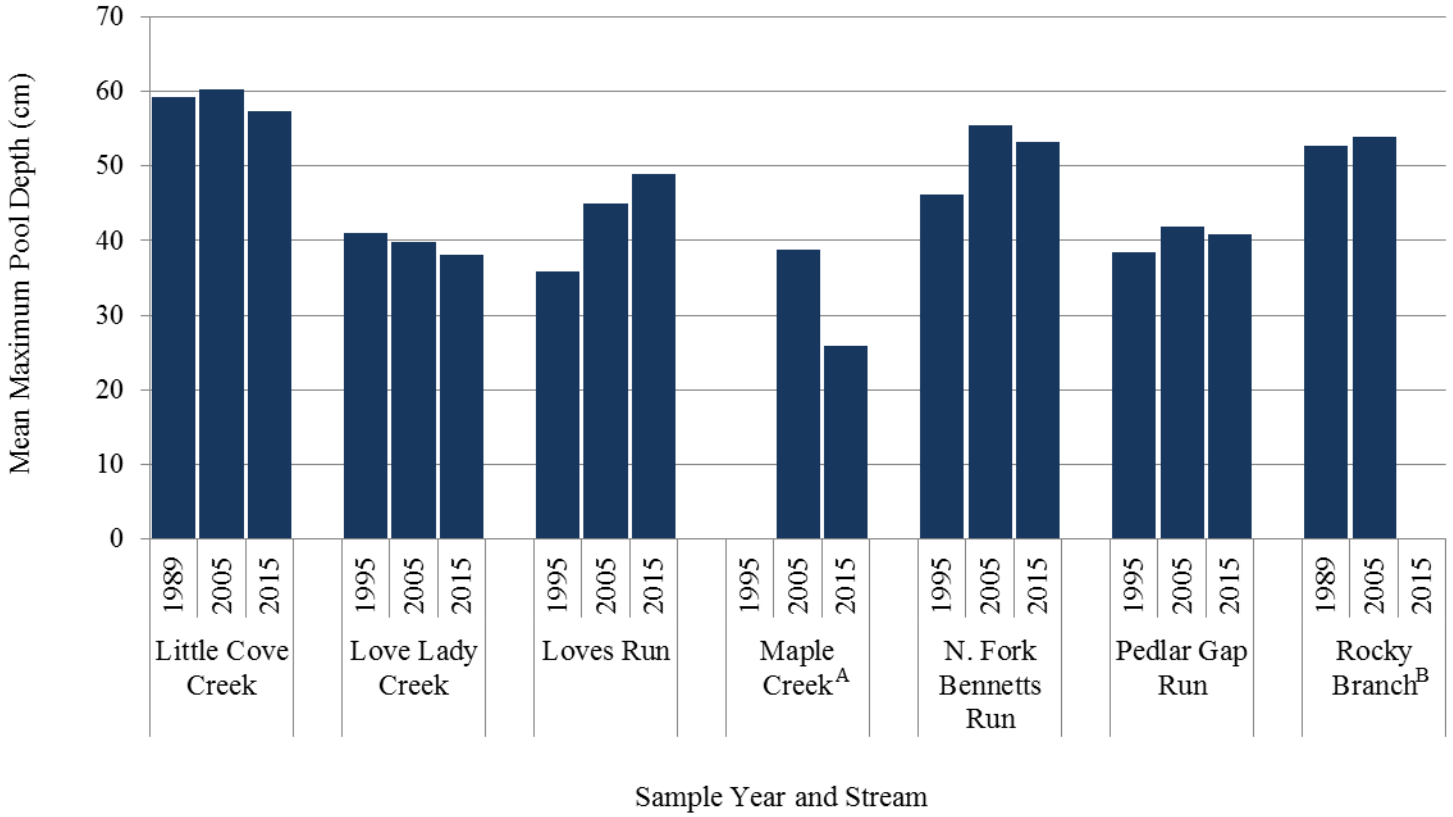

Figure 11 continued. Mean maximum pool depth (includes glide).

[A] Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded from between-year comparisons. The 1995 section is located ~1 km upstream of the 2005 and 2015 endpoint.

[B] Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

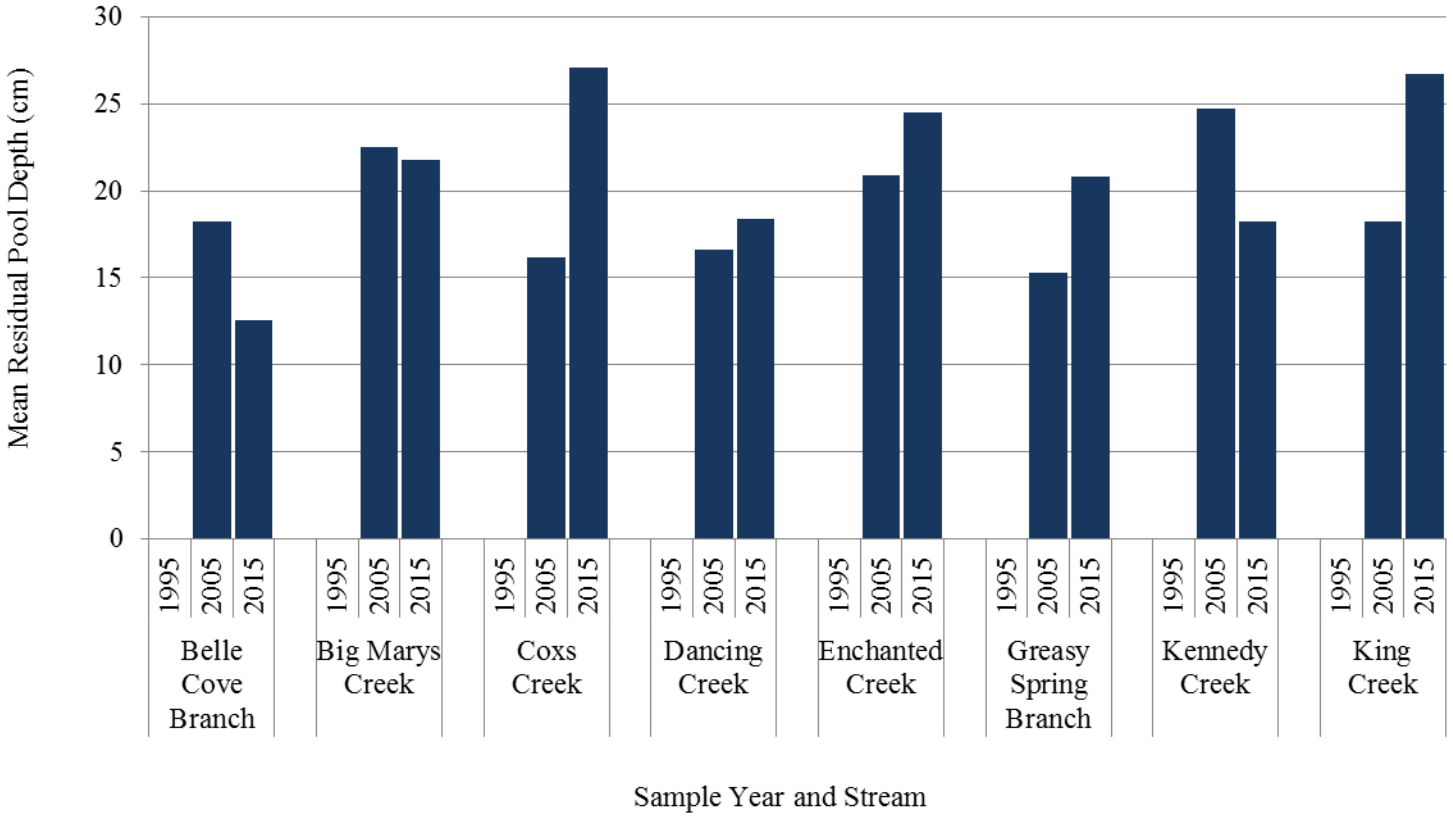

Figure 12. Mean residual pool depth (includes glide). Residual depth data was not collected in 1995.

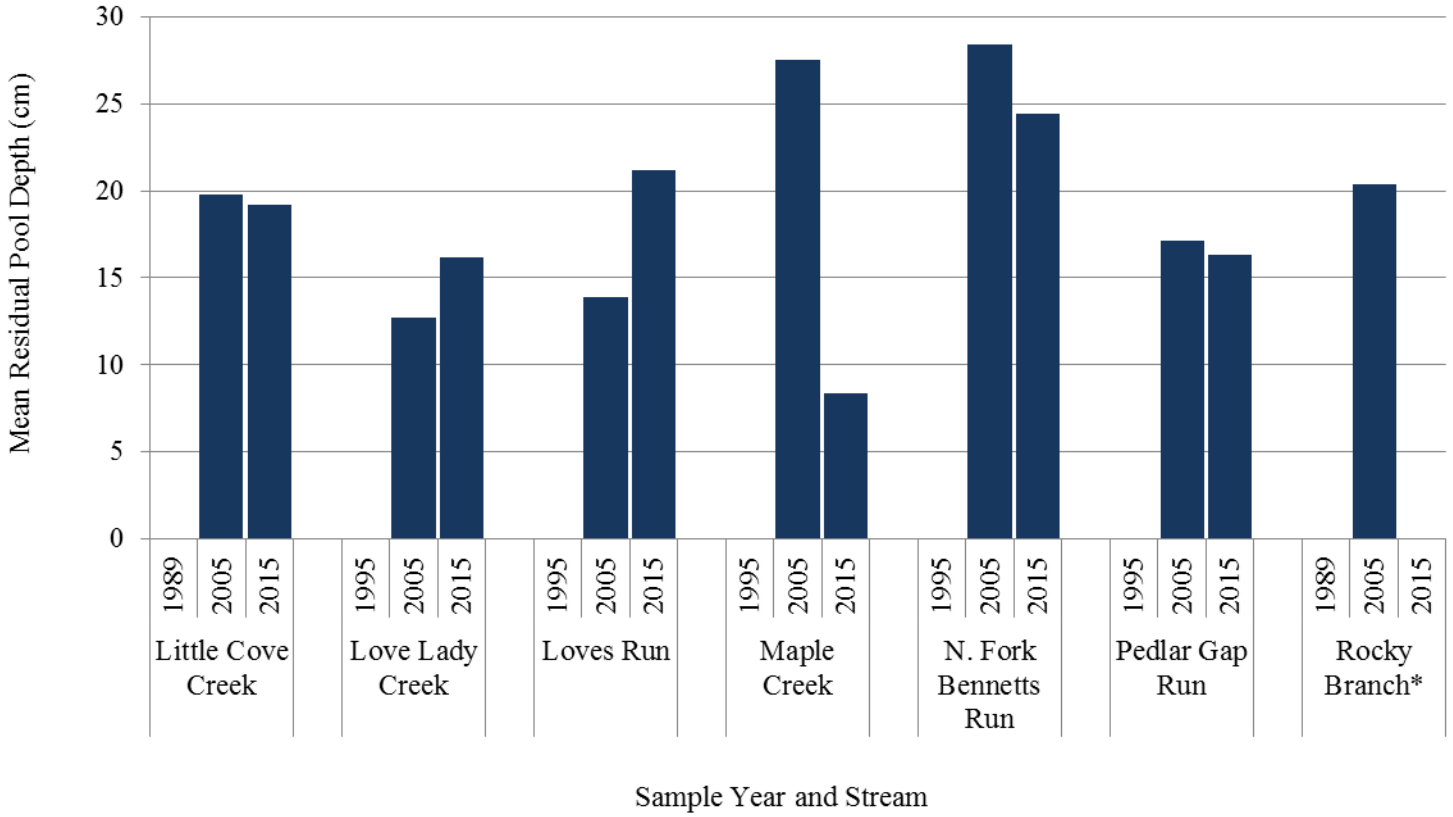

Figure 12 continued. Mean residual pool depth (includes glide). Residual depth data was not collected in 1995.

* Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

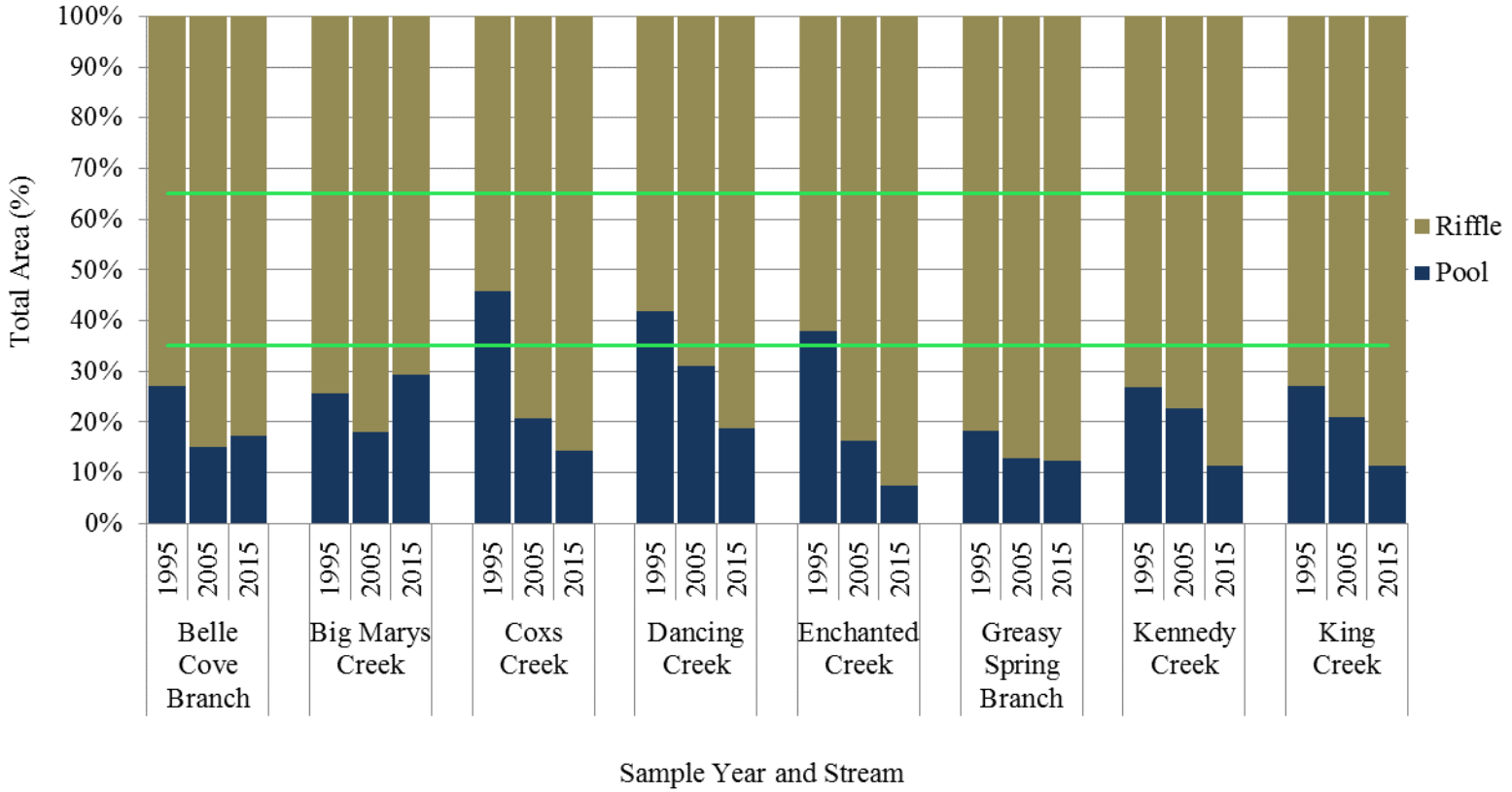

Figure 13. Percent pool (includes glide) and riffle (includes cascade and run) habitat area. Green lines indicate the GWJNF's desired future condition of 35-65% pool habitat.

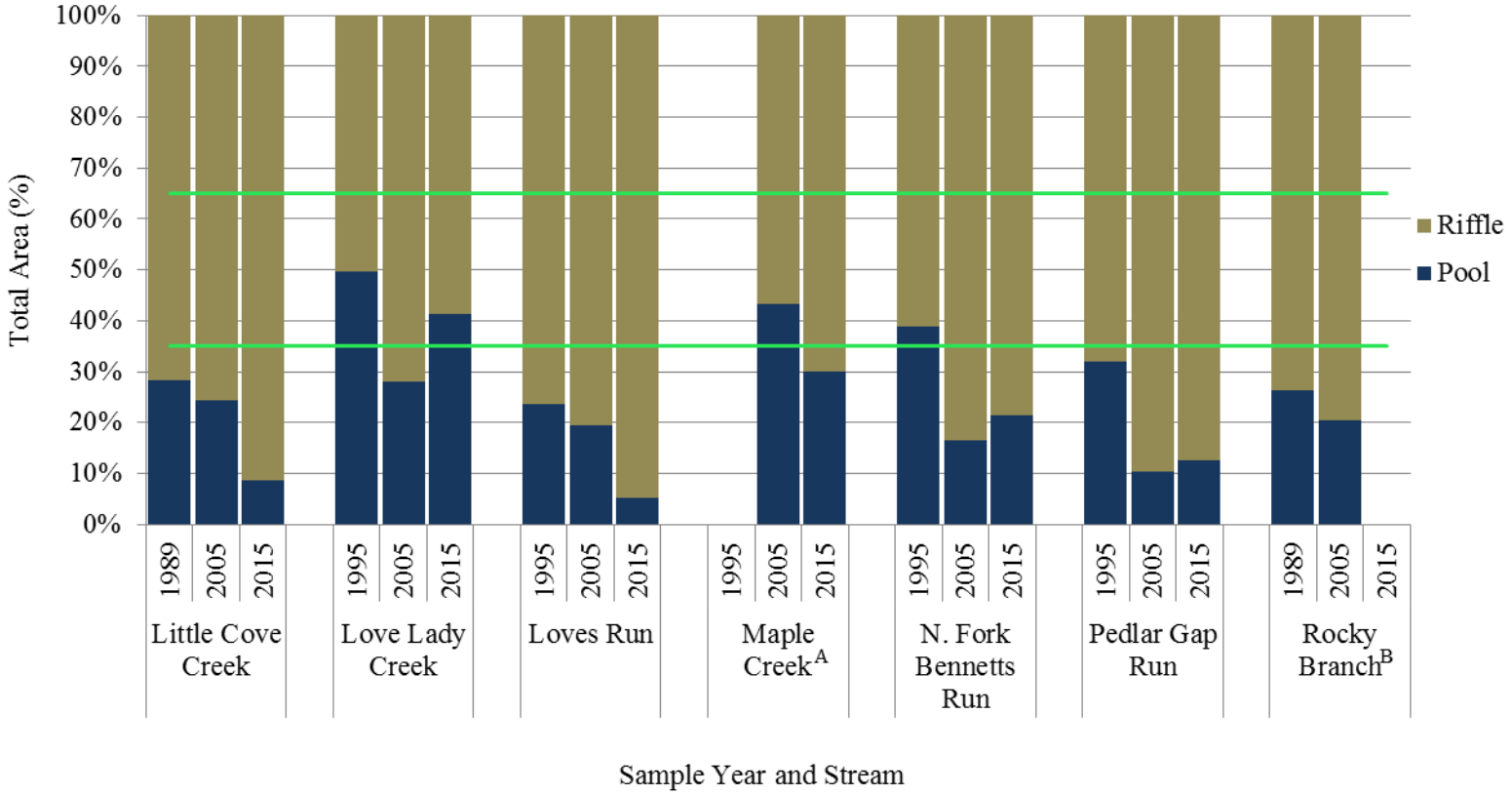

Figure 13 continued. Percent pool (includes glide) and riffle (includes cascade and run) habitat area. Green lines indicate the GWJNF's desired future condition of 35-65% pool habitat.

[A] Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded from between-year comparisons. The 1995 section is located ~1 km upstream of the 2005 and 2015 endpoint. For Maple Creek 2005 data, uncorrected visually estimated wetted stream widths used to calculate habitat area due to lack of measured paired samples.

[B] Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

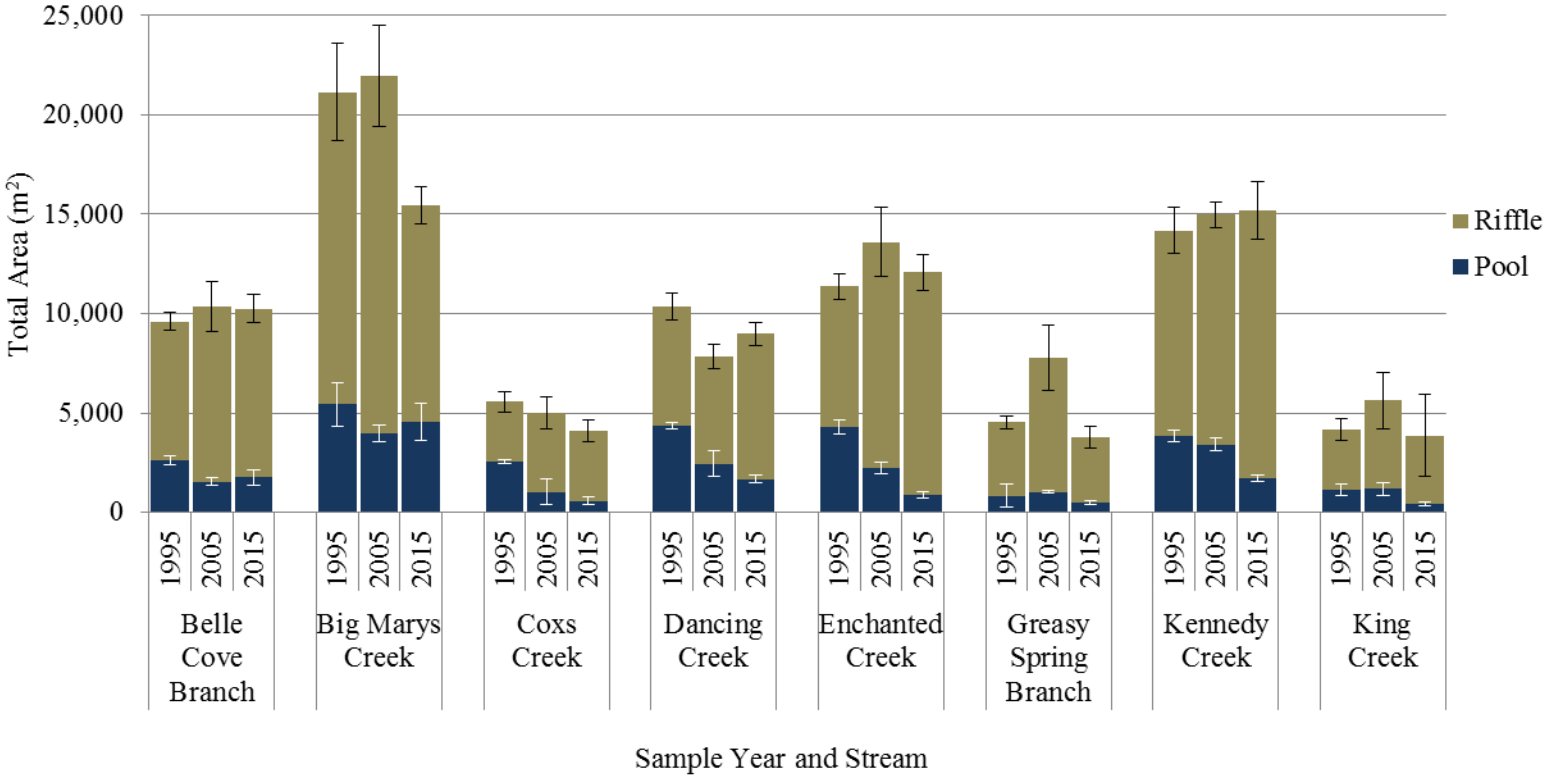

Figure 14. Total pool (includes glide) and riffle (includes cascade and run) habitat area (m^2).

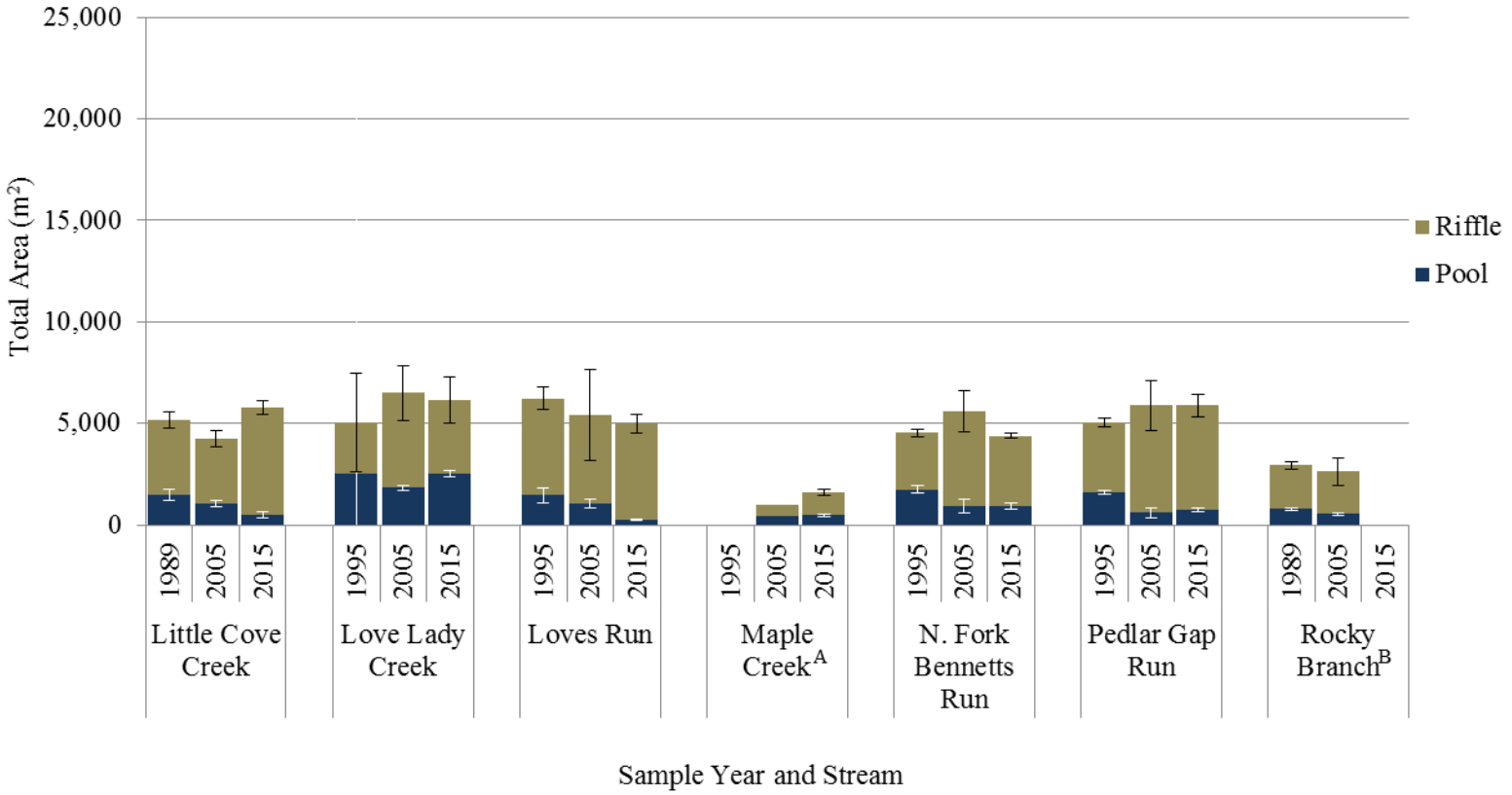

Figure 14 continued. Total pool (includes glide) and riffle (includes cascade and run) habitat area (m^2).

[A] Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded from between-year comparisons. The 1995 section is located ~1 km upstream of the 2005 and 2015 endpoint. For Maple Creek 2005 data, uncorrected visually estimated wetted stream widths used to calculate habitat area due to lack of measured paired samples.

[B] Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

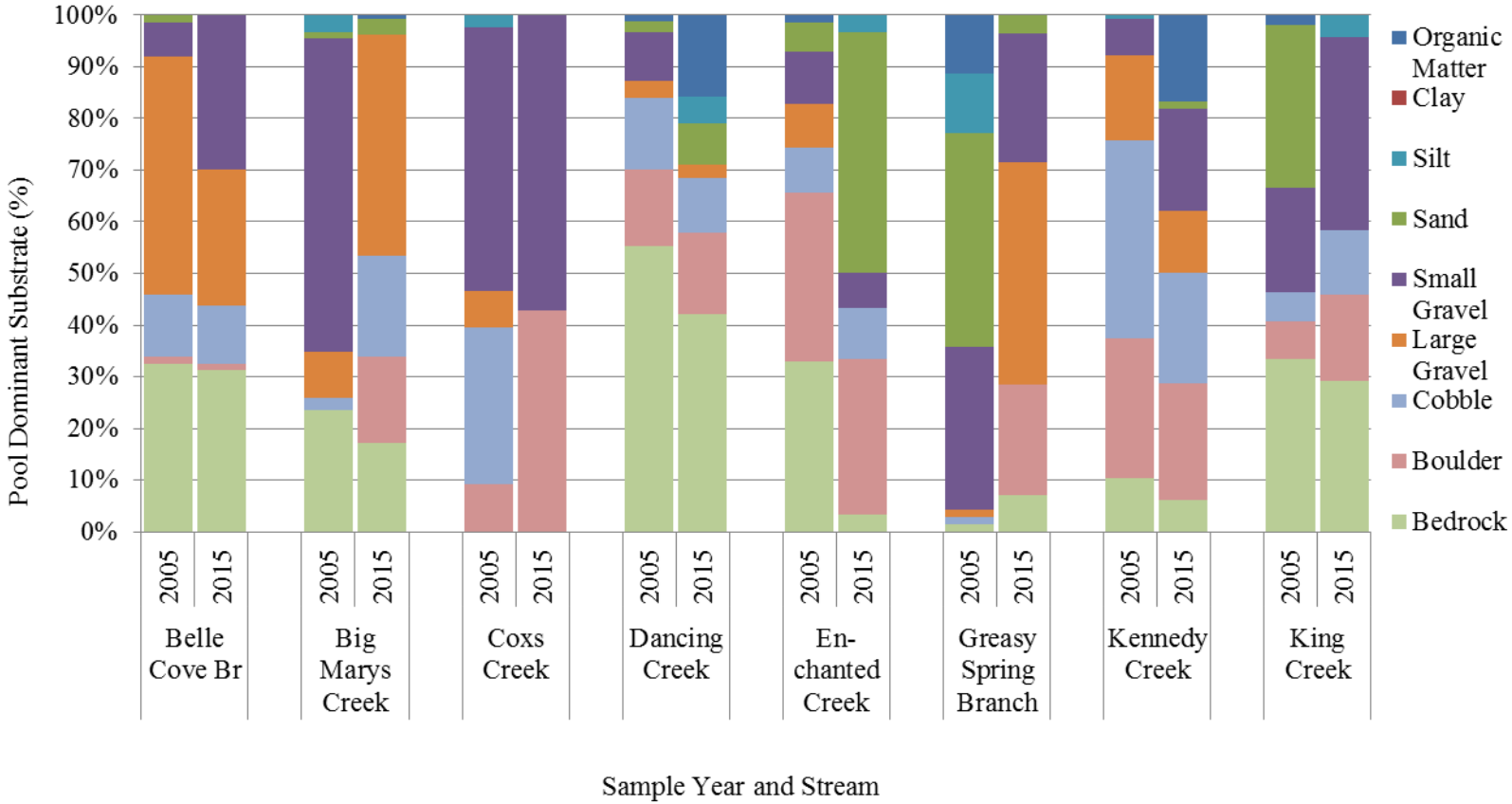

Figure 15. Percent dominant substrate category present in pools (includes glides). Substrate data was not collected in 1995. Substrate size categories: Organic Matter = dead leaves, detritus, etc.; Clay = sticky, holds form; Silt = slippery, doesn't hold form; Sand = silt-2 mm; Small Gravel = 3-16 mm; Large Gravel = 17-64 mm; Cobble = 65-256 mm; Boulder = >256 mm; Bedrock = solid rock.

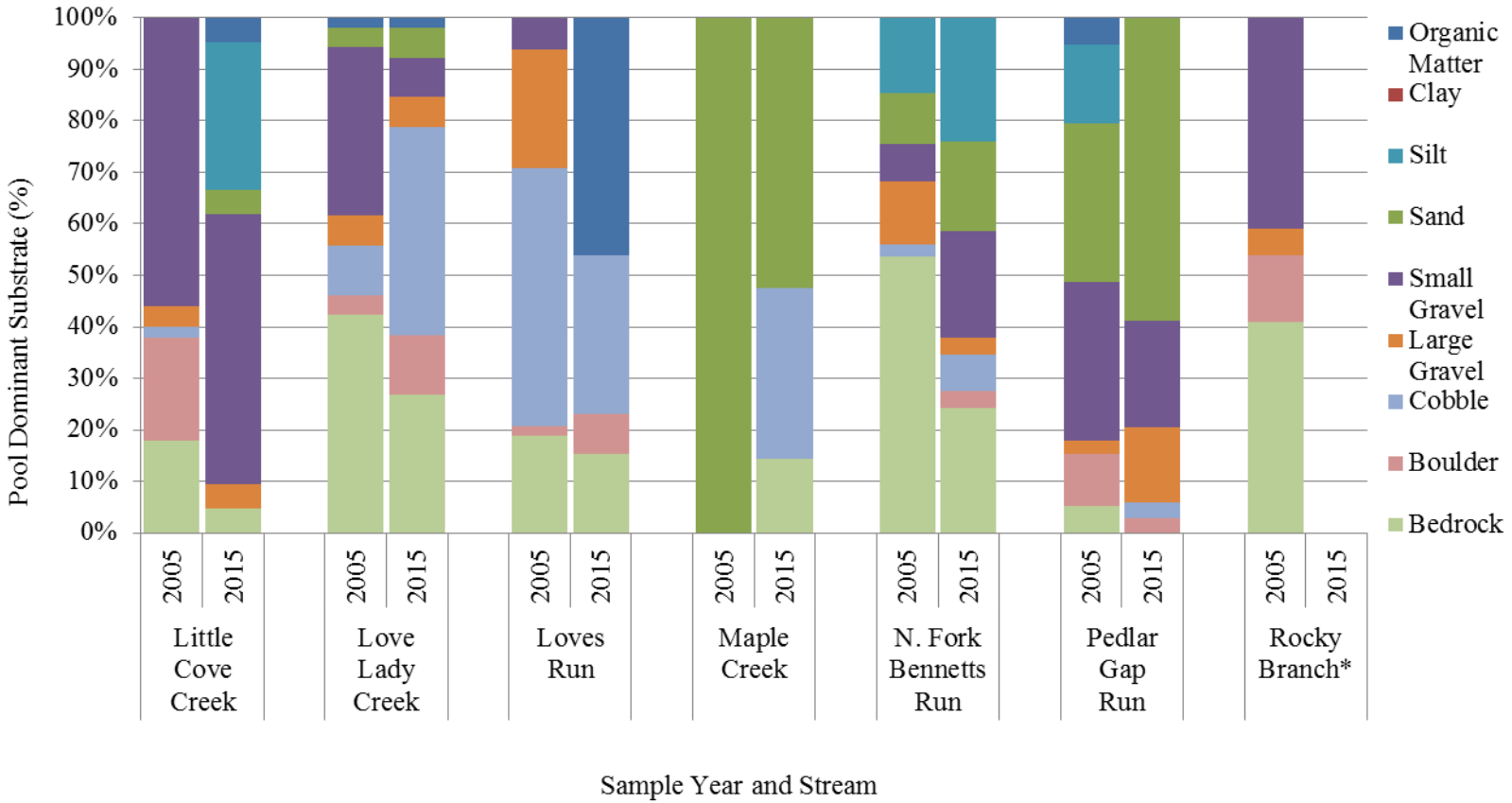

Figure 15 continued. Percent dominant substrate category present in pools (includes glides). Substrate data was not collected in 1995. Substrate size categories: Organic Matter = dead leaves, detritus, etc.; Clay = sticky, holds form; Silt = slippery, doesn't hold form; Sand = silt-2 mm; Small Gravel = 3-16 mm; Large Gravel = 17-64 mm; Cobble = 65-256 mm; Boulder = >256 mm; Bedrock = solid rock.

* Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

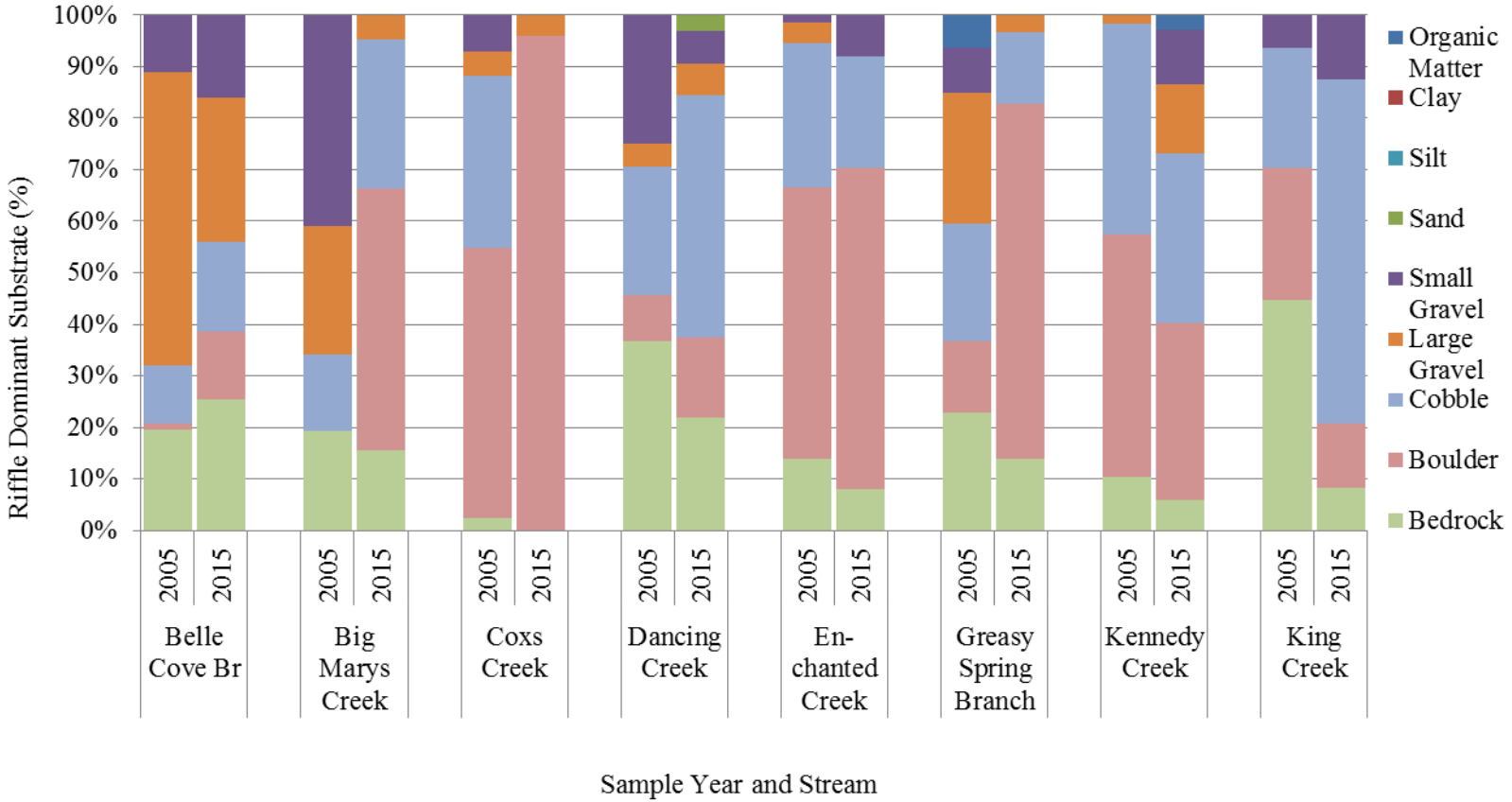

Figure 16. Percent dominant substrate category present in riffles (includes cascades and runs). Substrate data was not collected in 1995. Substrate size categories: Organic Matter = dead leaves, detritus, etc.; Clay = sticky, holds form; Silt = slippery, doesn't hold form; Sand = silt-2 mm; Small Gravel = 3-16 mm; Large Gravel = 17-64 mm; Cobble = 65-256 mm; Boulder = >256 mm; Bedrock = solid rock.

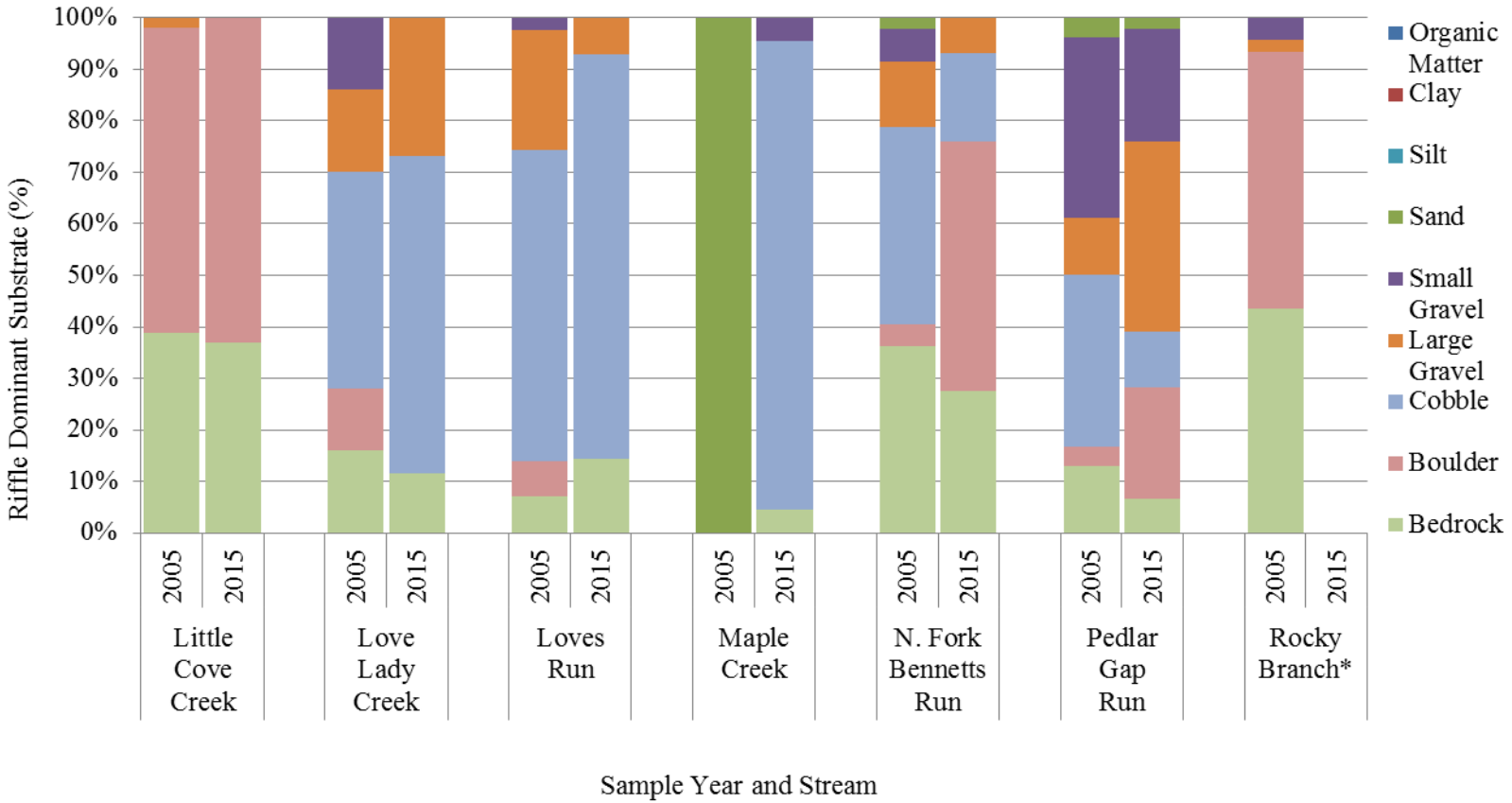

Figure 16 continued. Percent dominant substrate category present in riffles (includes cascades and runs). Substrate data was not collected in 1995. Substrate size categories: Organic Matter = dead leaves, detritus, etc.; Clay = sticky, holds form; Silt = slippery, doesn't hold form; Sand = silt-2 mm; Small Gravel = 3-16 mm; Large Gravel = 17-64 mm; Cobble = 65-256 mm; Boulder = >256 mm; Bedrock = solid rock.

* Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

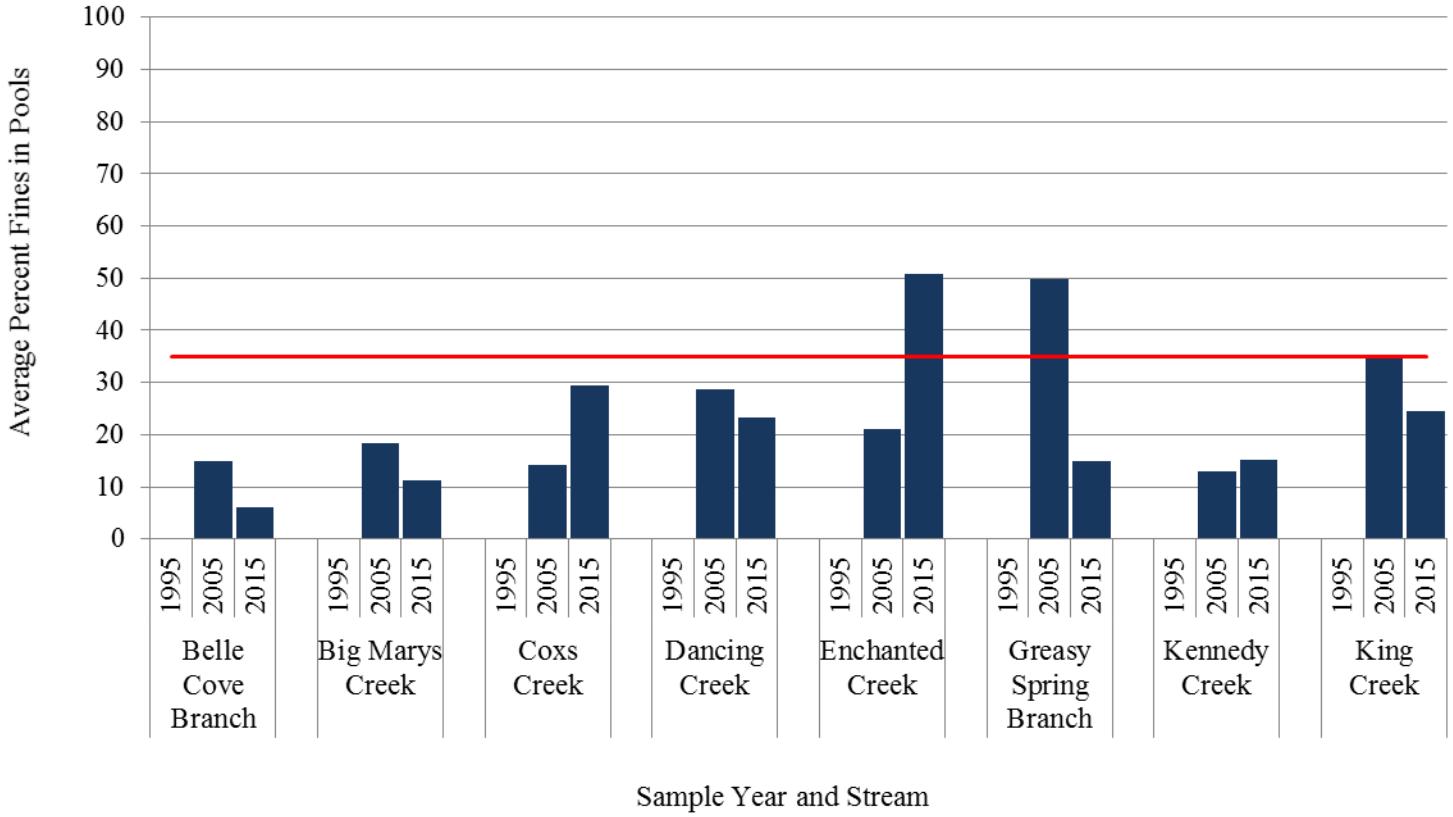

Figure 17. Percent of pool (includes glide) channel bottom comprised of fine sediment (sand, silt, and/or clay). Red line indicates 35% threshold at which fines can cause detrimental effects to stream fishes (Everest et al. 1987). Percent fines data was not collected in 1995.

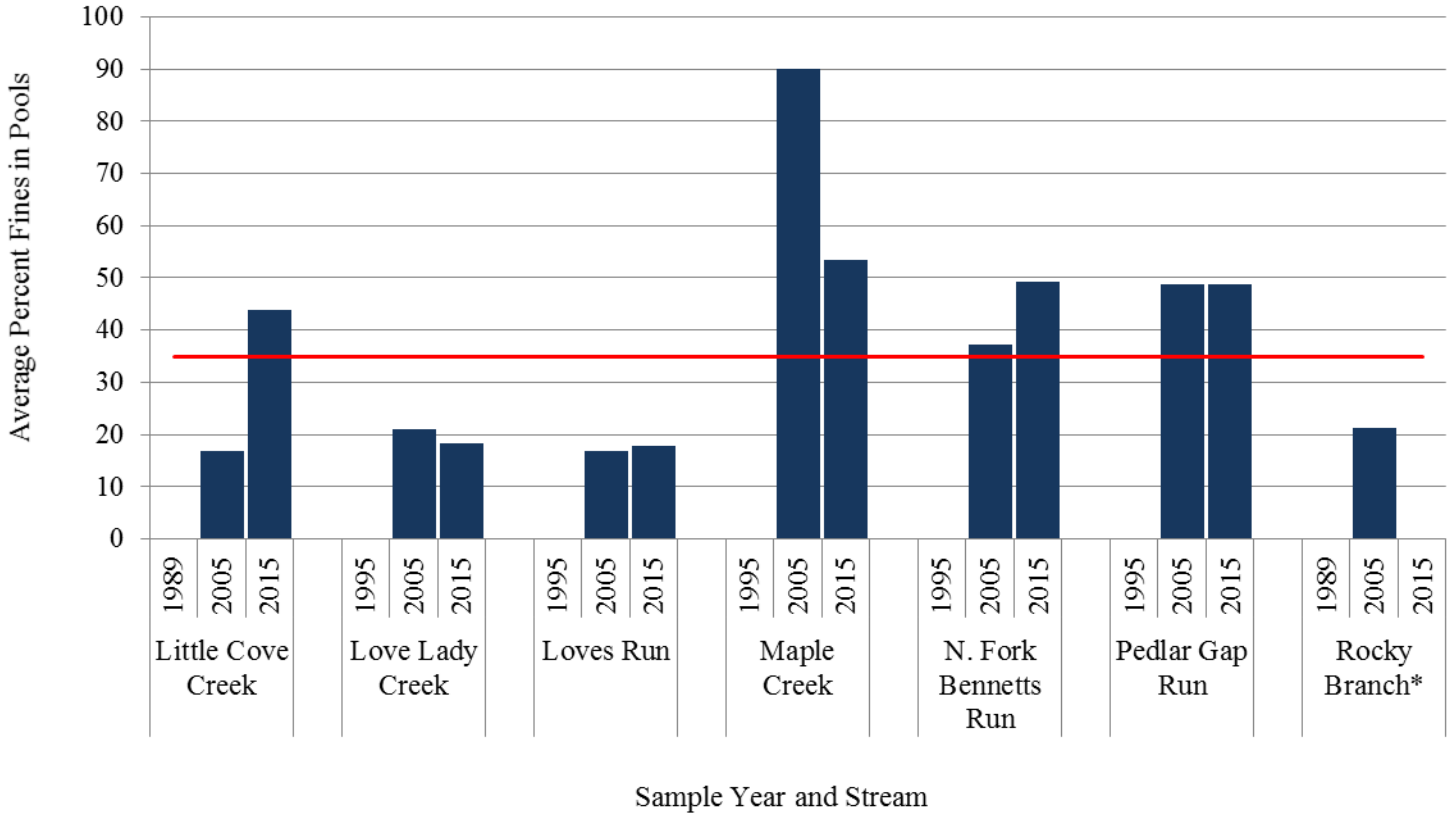

Figure 17 continued. Percent of pool (includes glide) channel bottom comprised of fine sediment (sand, silt, and/or clay). Red line indicates 35% threshold at which fines can cause detrimental effects to stream fishes (Everest et al. 1987). Percent fines data was not collected in 1995.

* Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

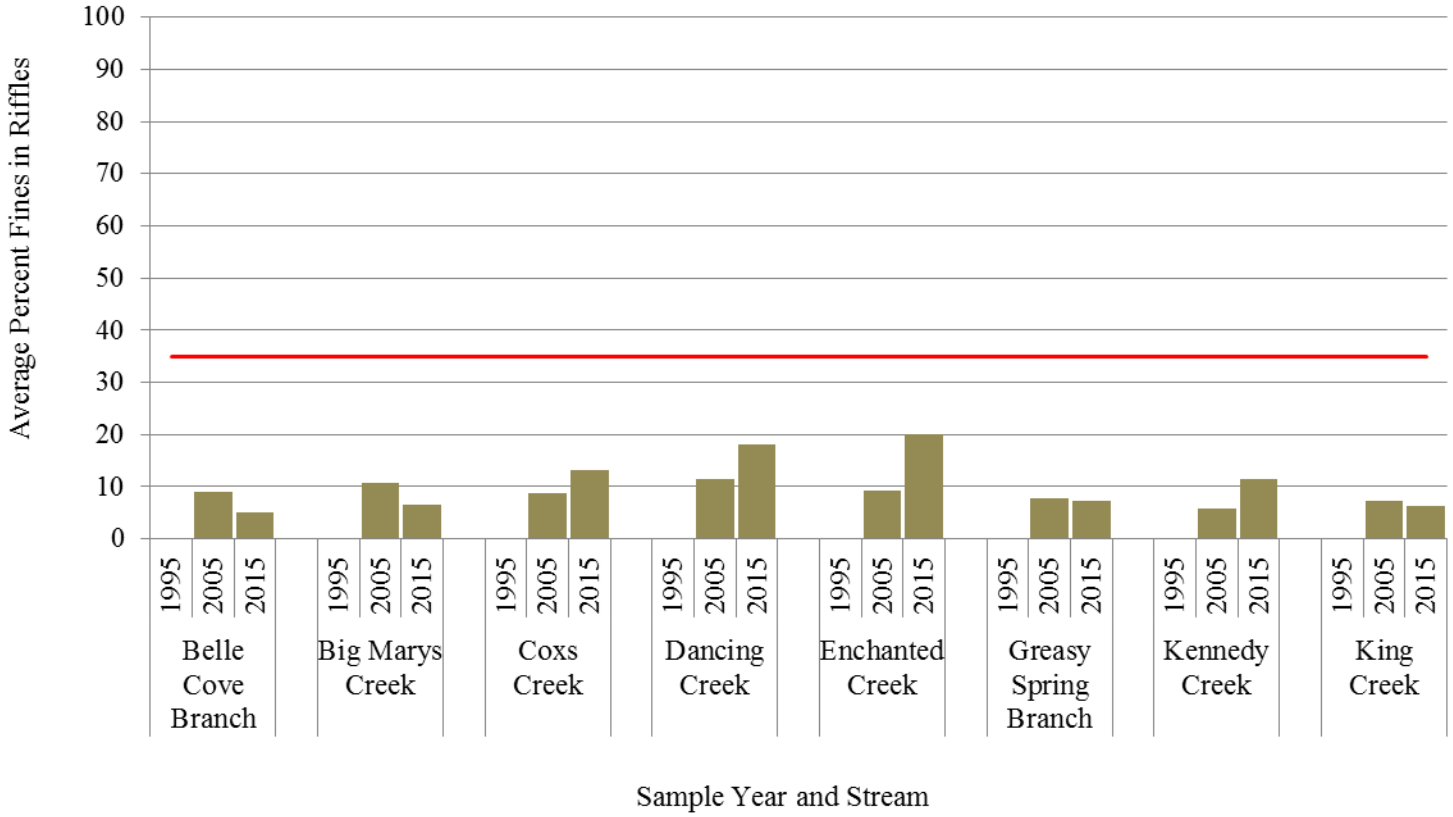

Figure 18. Percent of riffle (includes cascade and run) channel bottom comprised of fine sediment (sand, silt, and/or clay). Red line indicates 35% threshold at which fines can cause detrimental effects to stream fishes (Everest et al. 1987). Percent fines data was not collected in 1995.

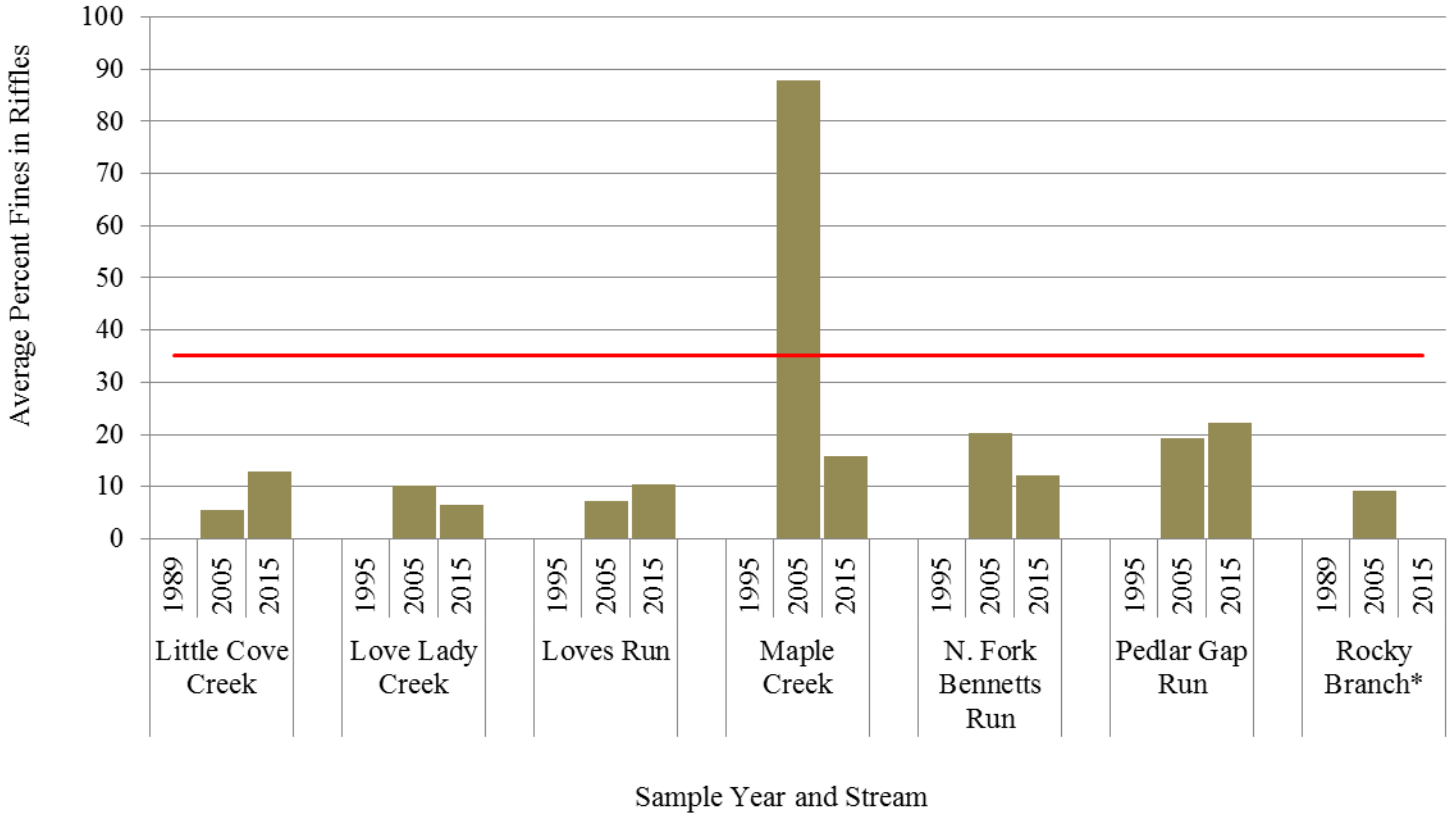

Figure 18 continued. Percent of riffles (includes cascade and run) channel bottom comprised of fine sediment (sand, silt, and/or clay). Red line indicates 35% threshold at which fines can cause detrimental effects to stream fishes (Everest et al. 1987). Percent fines data was not collected in 1995.

* Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

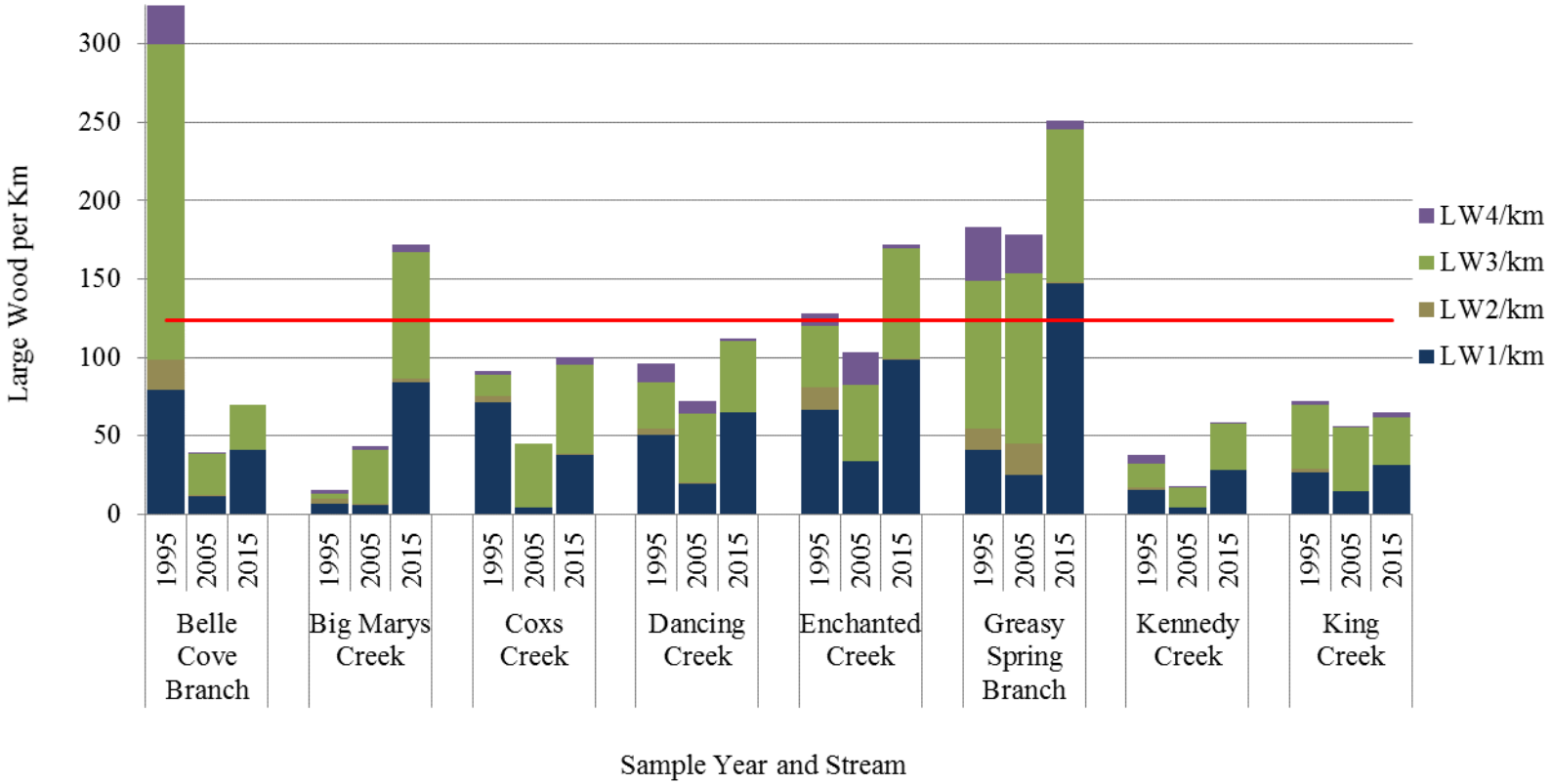

Figure 19. Quantity of large wood (LW; dead and down, any part within bankfull channel) per kilometer. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter. Rootwads were not tallied in 1995 and are not presented for 2005 and 2015 in this figure. Red line indicates GWJNF recommended 124 LW/km to maintain habitat diversity for aquatic species (USDA 2004 and 2014).

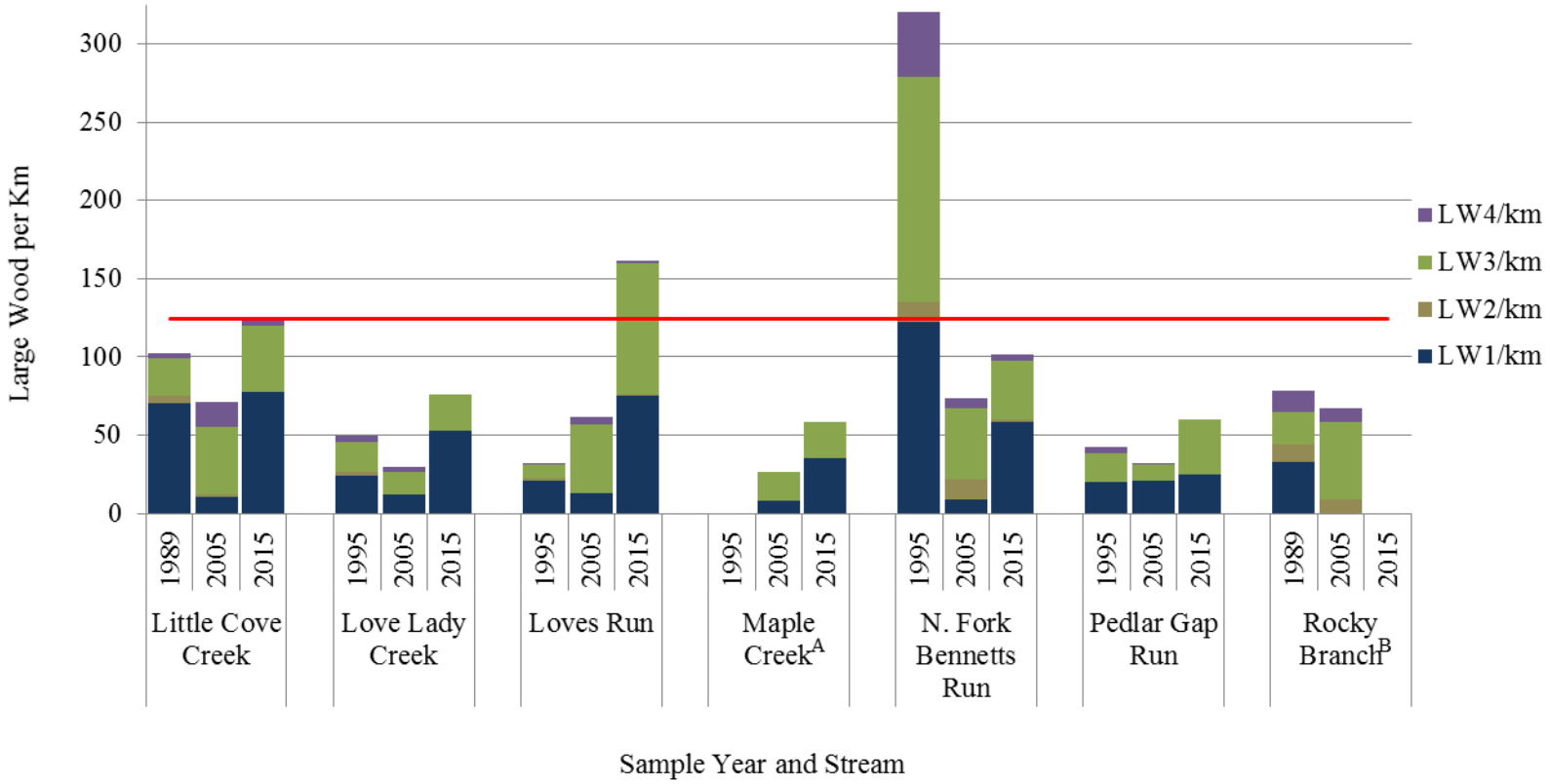

Figure 19 continued. Quantity of large wood (LW; dead and down, any part within bankfull channel) per kilometer. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter. Rootwads were not tallied in 1995 and are not presented for 2005 and 2015 in this figure. Red line indicates GWJNF recommended 124 LW/km to maintain habitat diversity for aquatic species (USDA 2004 and 2014).

[A] Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded from between-year comparisons. The 1995 section is located ~1 km upstream of the 2005 and 2015 endpoint.
[B] Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

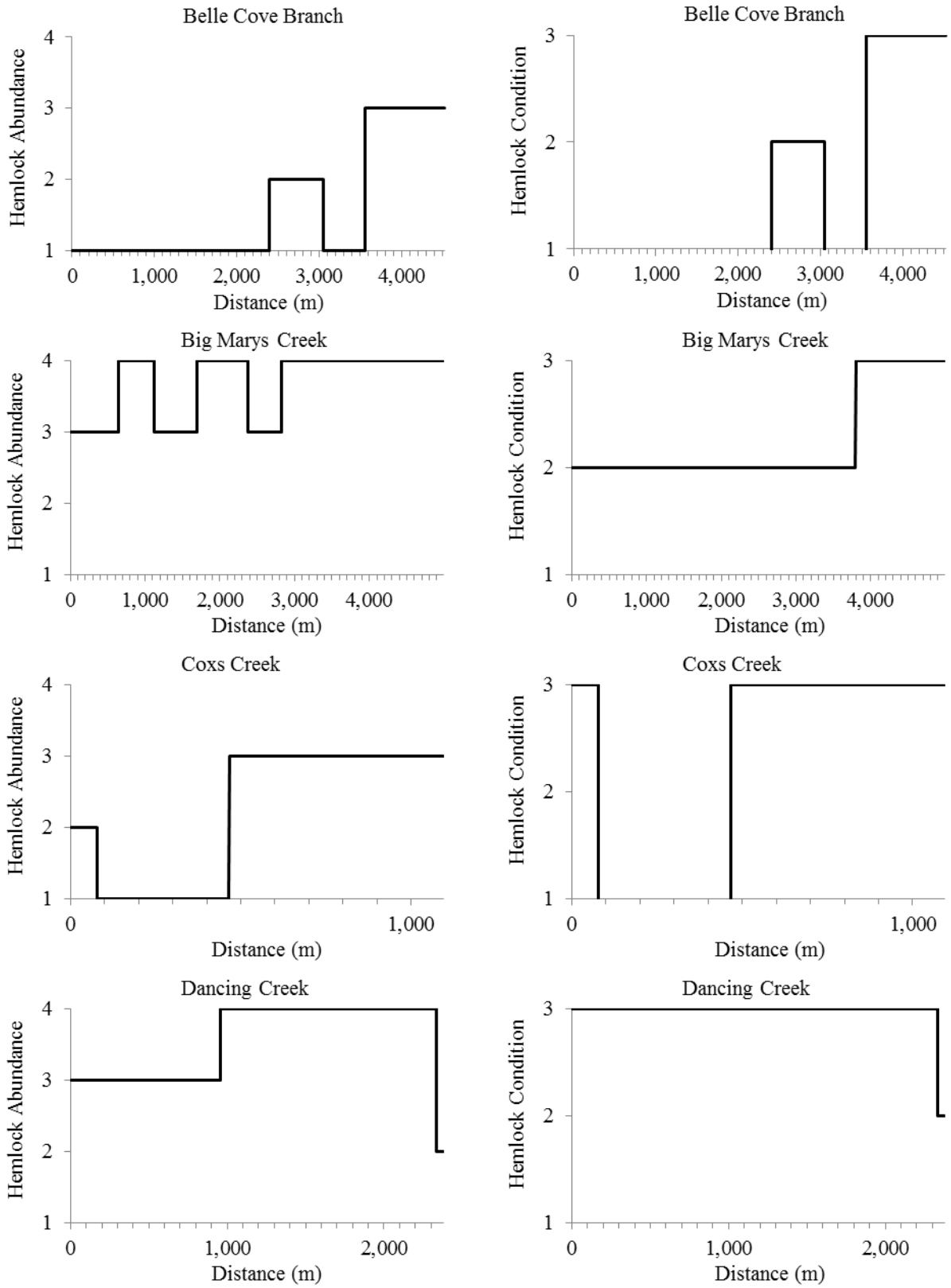

Figure 20. Riparian hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each 2015 stream inventory (see appendix A for detailed categories).

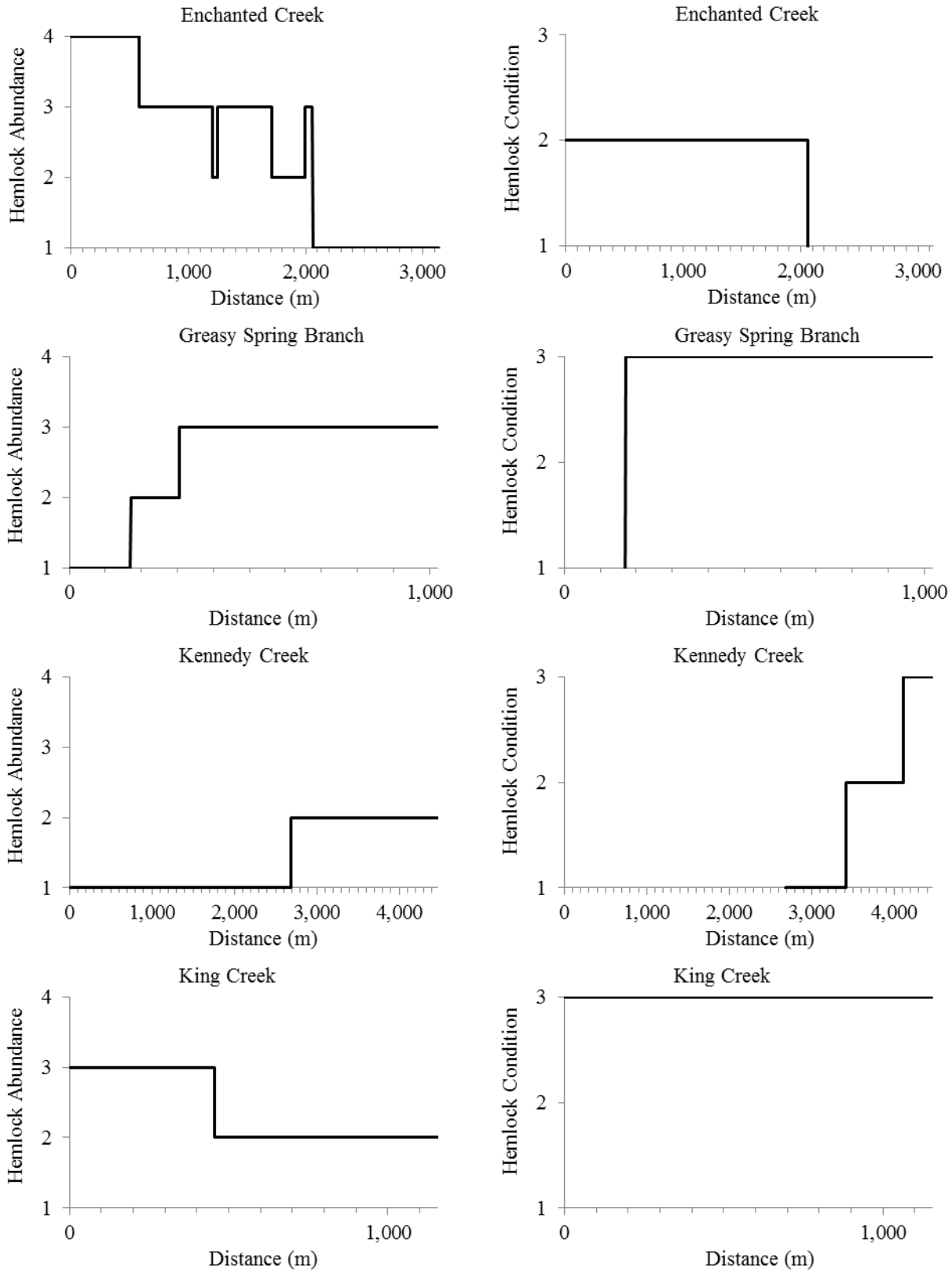

Figure 20 continued. Riparian hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each 2015 stream inventory (see appendix A for detailed categories).

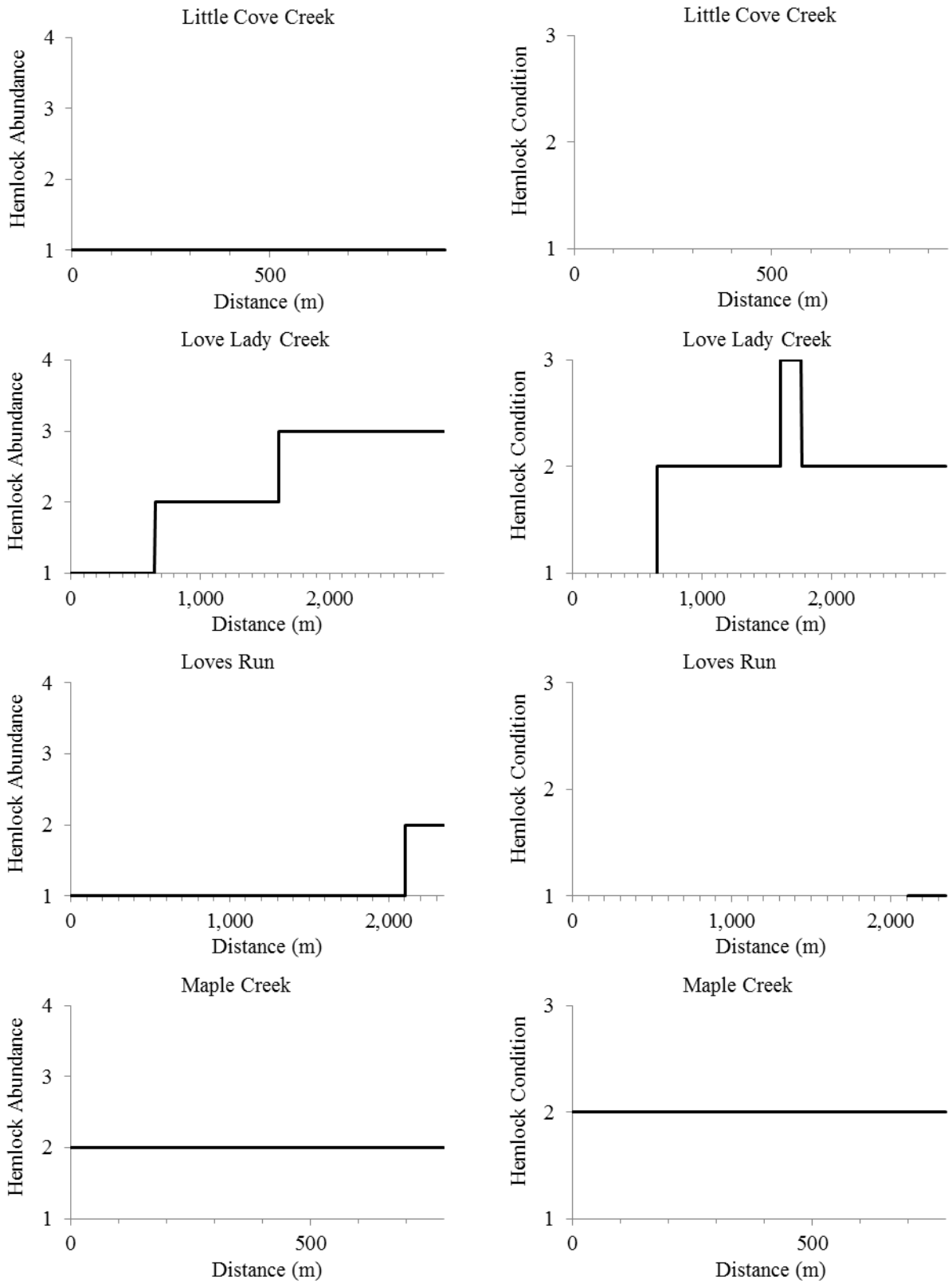

Figure 20 continued. Riparian hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each 2015 stream inventory (see appendix A for detailed categories).

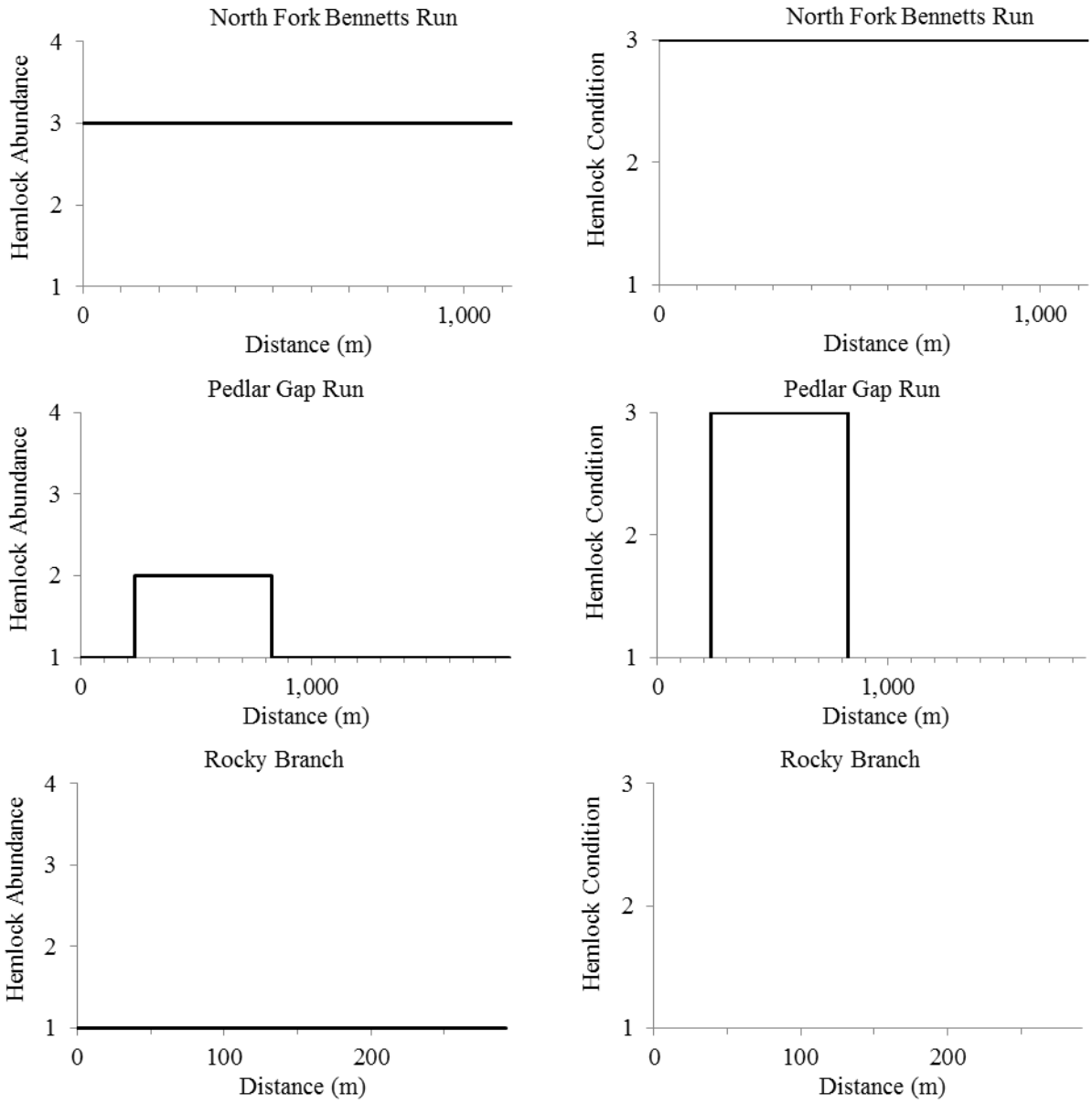

Figure 20 continued. Riparian hemlock abundance (1 = none; 2 = 1-10; 3 = 11-50, 4 = >50) and condition (1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead) shown longitudinally for each 2015 stream inventory (see appendix A for detailed categories).

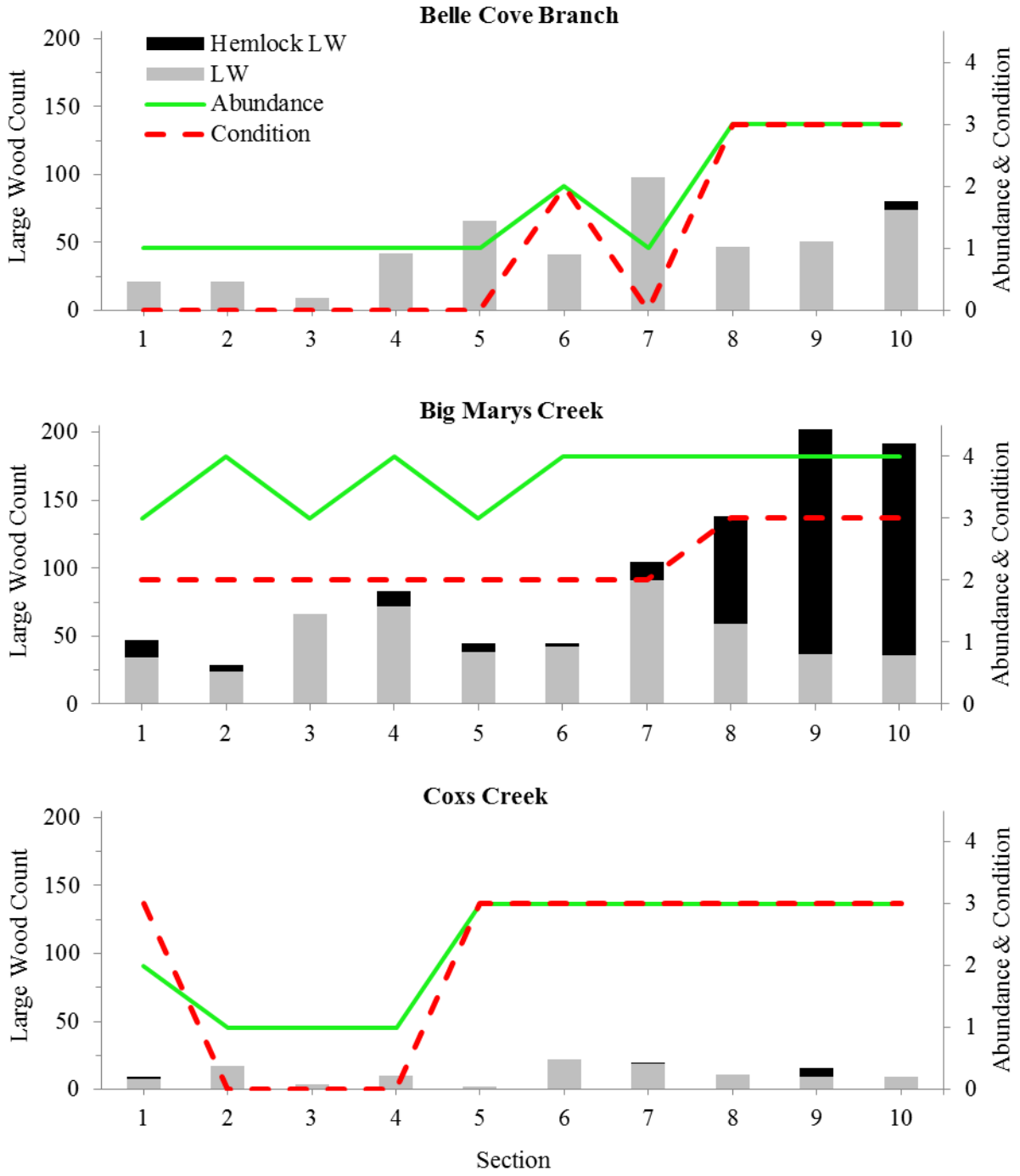

Figure 21. Large wood counts and hemlock abundance and condition for 2015 inventories. X-axis represents total length of the inventory divided evenly among 10 sections, for example if a stream inventory was 1,000 m long, then section 1 sums large wood counts for 0 - 100 m, section 2 for 101 - 200 m, etc. Sections do not represent equal distances among streams, thus LW counts should only be used to examine trends within streams, not among streams. Primary y-axis is for count of hemlocks (black bar) and all other species (grey bar), combining all LW size classes. Secondary y-axis is riparian hemlock abundance (solid green line) and condition (dashed red line). For hemlock abundance 1 = none; 2 = 1-10; 3 = 11-50, 4 = >50. For hemlock condition 0 = none, 1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead.

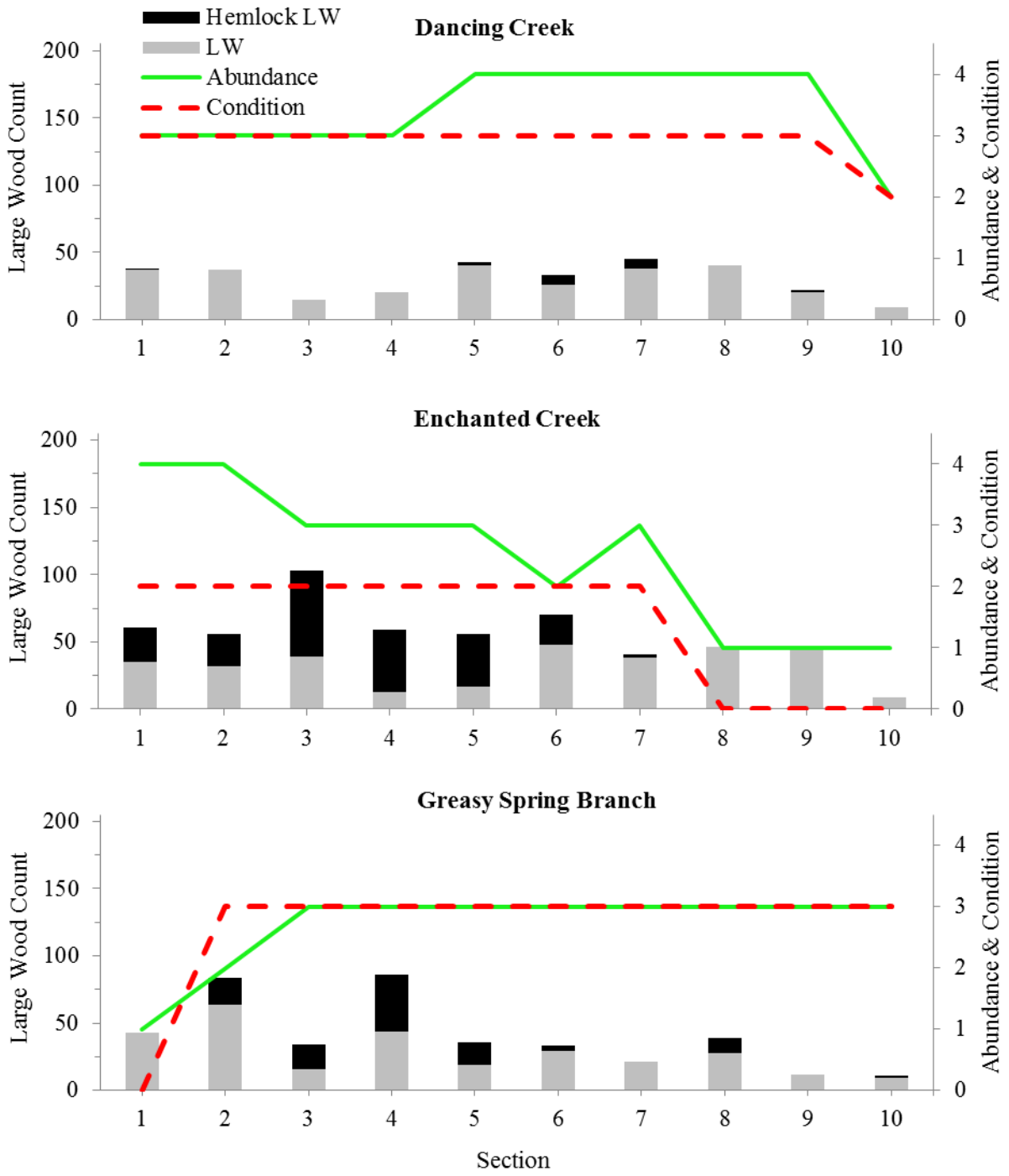

Figure 21 continued. Large wood counts and hemlock abundance and condition for 2015 inventories. X-axis represents total length of the inventory divided evenly among 10 sections, for example if a stream inventory was 1,000 m long, then section 1 sums large wood counts for 0 - 100 m, section 2 for 101 - 200 m, etc. Sections do not represent equal distances among streams, thus LW counts should only be used to examine trends within streams, not among streams. Primary y-axis is for count of hemlocks (black bar) and all other species (grey bar), combining all LW size classes. Secondary y-axis is riparian hemlock abundance (solid green line) and condition (dashed red line). For hemlock abundance 1 = none; 2 = 1-10; 3 = 11-50, 4 = >50. For hemlock condition 0 = none, 1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead.

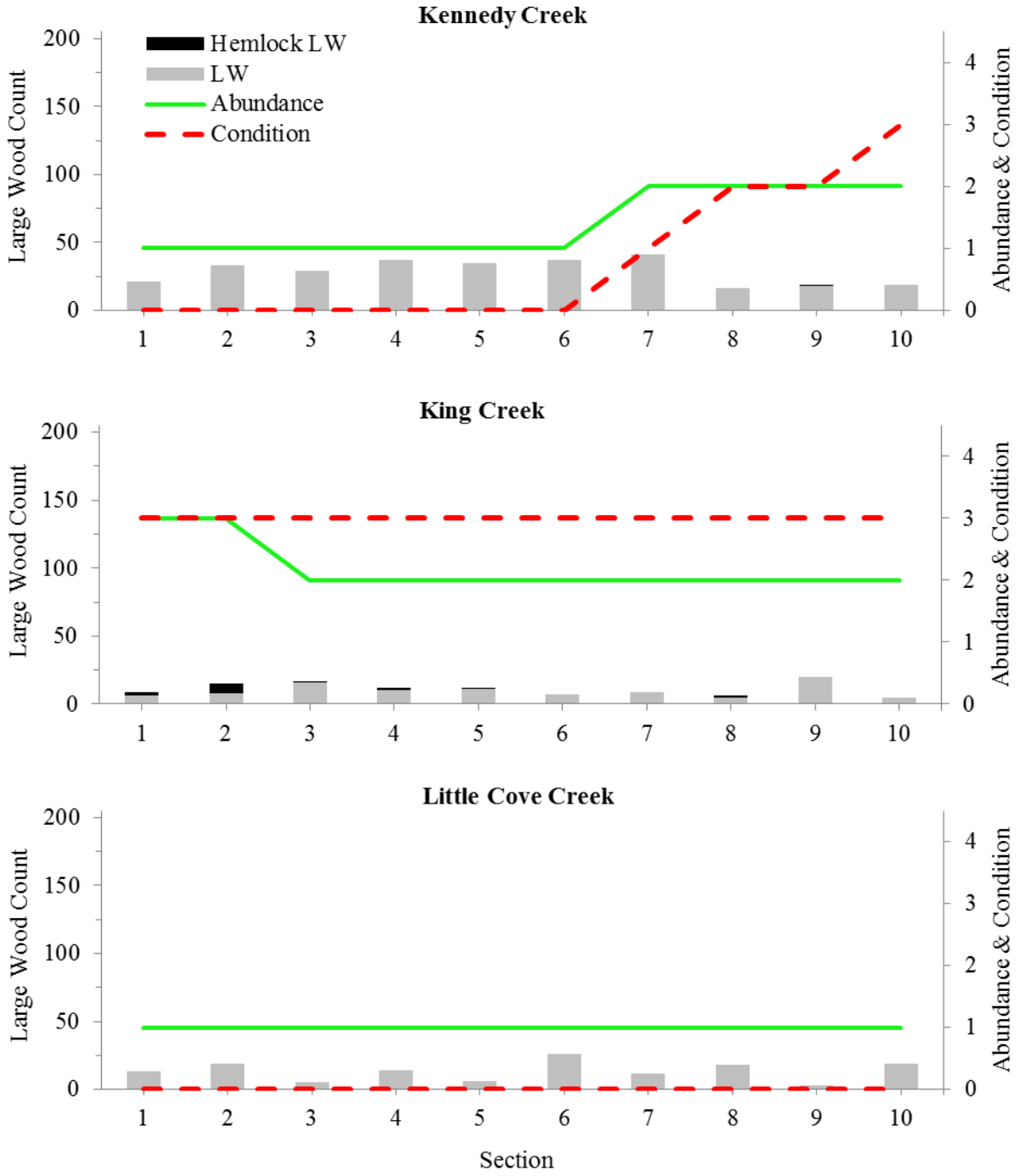

Figure 21 continued. Large wood counts and hemlock abundance and condition for 2015 inventories. X-axis represents total length of the inventory divided evenly among 10 sections, for example if a stream inventory was 1,000 m long, then section 1 sums large wood counts for 0 - 100 m, section 2 for 101 - 200 m, etc. Sections do not represent equal distances among streams, thus LW counts should only be used to examine trends within streams, not among streams. Primary y-axis is for count of hemlocks (black bar) and all other species (grey bar), combining all LW size classes. Secondary y-axis is riparian hemlock abundance (solid green line) and condition (dashed red line). For hemlock abundance 1 = none; 2 = 1-10; 3 = 11-50, 4 = >50. For hemlock condition 0 = none, 1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead.

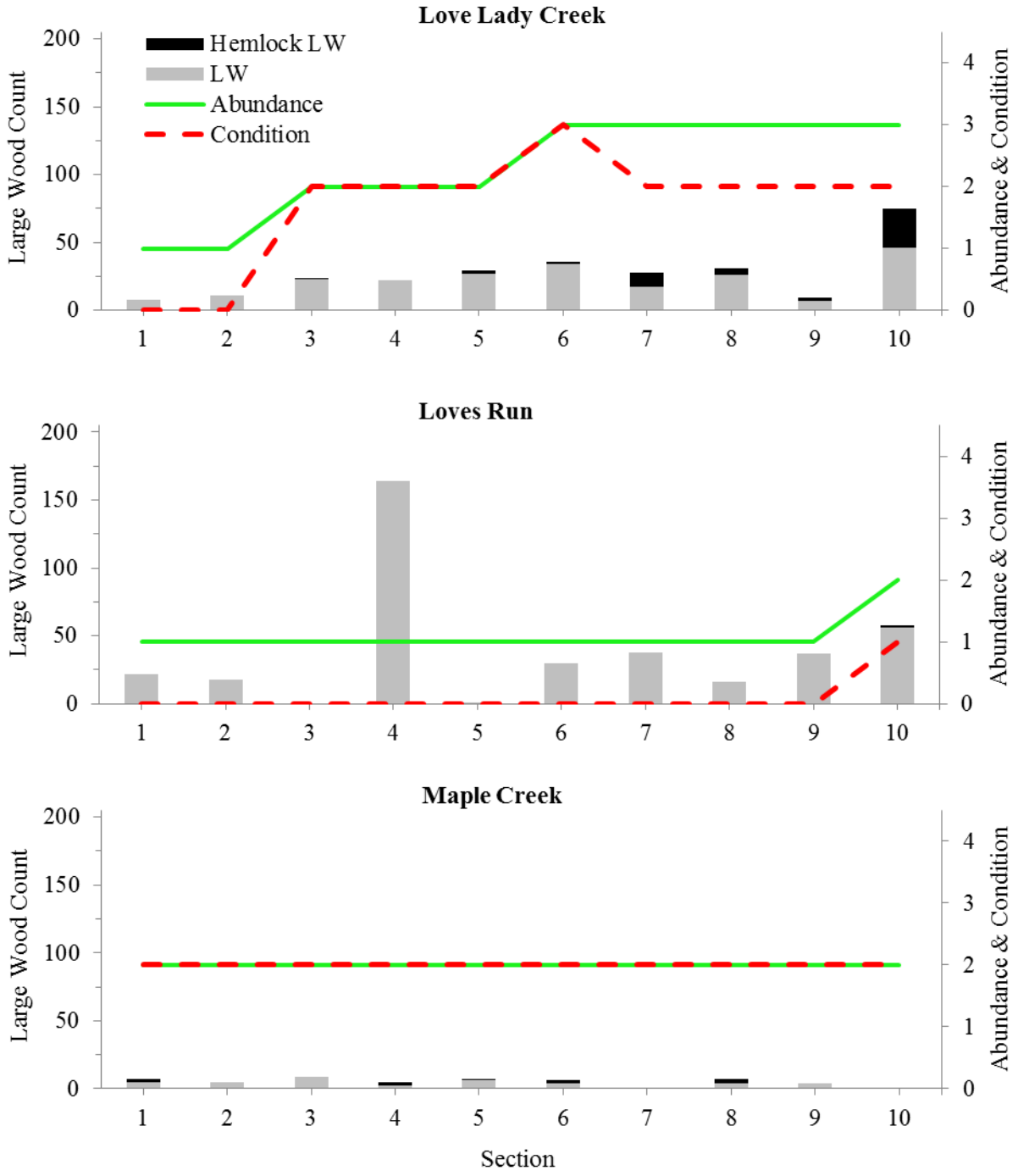

Figure 21 continued. Large wood counts and hemlock abundance and condition for 2015 inventories. X-axis represents total length of the inventory divided evenly among 10 sections, for example if a stream inventory was 1,000 m long, then section 1 sums large wood counts for 0 - 100 m, section 2 for 101 - 200 m, etc. Sections do not represent equal distances among streams, thus LW counts should only be used to examine trends within streams, not among streams. Primary y-axis is for count of hemlocks (black bar) and all other species (grey bar), combining all LW size classes. Secondary y-axis is riparian hemlock abundance (solid green line) and condition (dashed red line). For hemlock abundance 1 = none; 2 = 1-10; 3 = 11-50, 4 = >50. For hemlock condition 0 = none, 1 = Healthy/Light Infestation, 2 = Infested, 3 = Dead.

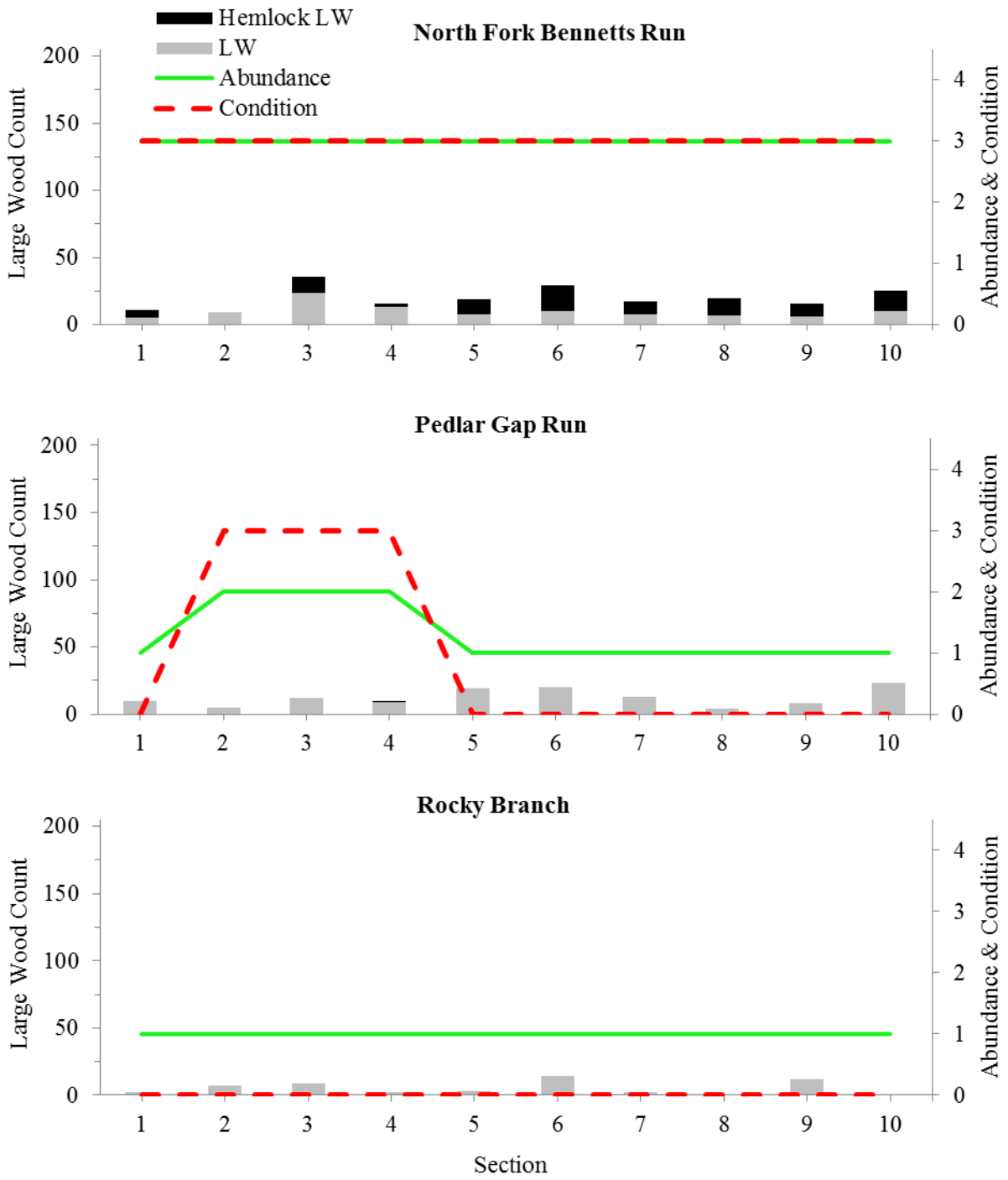

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Table 1. BVET inventory and comparison length (km) of streams on the Pedlar Ranger District in 1995, 2005, and 2015. Comparison length (km) is the inventory length adjusted in order to be as similar as possible between years for data comparison. Inventory lengths were trimmed based on the distance difference between the inventory start/end location and fixed feature locations such as tributaries, fords, or culverts whenever possible. Comparison lengths may still vary somewhat between years by stream due to hip-chain measurement variability.

		Inventory Length (km)			Comparison Length (km)		
Stream	Quad	1995	2005	2015	1995	2005	2015
Belle Cove Branch	Glasgow	5.9	4.0	4.8	4.2	4.0	4.0
Big Marys Creek	Vesuvius/Montebello	7.2	7.9	5.4	5.4	5.4	5.4
Coxs Creek	Massies mill	1.6	1.2	1.2	1.6	1.2	1.2
Dancing Creek	Big Island/Buena Vista	4.3	2.6	2.6	2.9	2.6	2.6
Enchanted Creek[A]	Buena Vista	4.0	3.8	3.1	3.1	2.9	3.1
Greasy Spring Branch	Montebello	1.8	1.9	1.6	1.8	1.9	1.6
Kennedy Creek	Big Levels	4.4	4.5	4.5	4.4	4.5	4.5
King Creek	Montebello/Massies Mill	1.7	1.7	1.7	1.7	1.7	1.7
Little Cove Creek	Forks of Buffalo	1.7[B]	1.2	1.1	1.2	1.2	1.1
Love Lady Creek	Big Island/Buena Vista	2.0	2.4	2.9	2.0	2.1	2.2
Loves Run	Big Levels	2.5	2.3	2.3	2.5	2.3	2.3
Maple Creek	Big Island	0.8[C]	0.6	0.9	-	0.6	0.9
North Fork Bennetts Run	Glasgow/Buena Vista	1.8	2.4	1.8	1.8	1.8	1.8
Pedlar Gap Run	Buena Vista	2.7	1.9	2.0	2.1	1.9	2.0
Rocky Branch	Forks of Buffalo	1.0[D]	1.1	0.3[E]	-	-	-

[A] Enchanted Creek lower section lengths were 2.4 km 2015, 2.2 km 2005, and NA 1995; upper section lengths were 0.7 km 2015, 1.6 km 2005, and NA 1995.

[B] Little Cove Creek was inventoried in 1989.

[C] Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded from between-year comparisons. The 1995 section is located ~1 km upstream of the 2005 and 2015 endpoint.

[D] Rocky Branch was inventoried in 1989.

[E] Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

Table 2. Summary of descriptive start and end inventory locations.

Stream	Inventory Start Location 1995, 2005, & 2015	Inventory End Location 1995	2005	2015
Belle Cove Branch	USFS boundary; downstream of Rd. 501	Confluence with unnamed tributary	Confluence with unnamed tributary	End of long riffle after left bend; at 30m long, 10m high cliff on left streambank
Big Marys Creek	USFS boundary; along Rd. 104	No description provided (7.2 km from start)	No description provided (7.9 km from start)	No description provided (5.4 km from start)
Coxs Creek	USFS boundary; near Rd. 1175	Confluence with unnamed tributary	Confluence with unnamed tributary	Upstream of unnamed tributary
Dancing Creek	USFS boundary	National Park Service boundary	376 m upstream of pipeline	Just upstream of Rd. 317 natural ford
Enchanted Creek (lower)	Confluence with Pedlar R.	USFS boundary	USFS boundary	USFS boundary
Enchanted Creek (upper)	Ford behind USFS gate off Rd. 607	No description provided (approx. 200 m upstream of 2005 endpoint)	Stream splits into 2 small tributaries	Confluence with Bluff Creek
Greasy Spring Branch	Confluence with South Fork Pimey River	No description provided (approx. 100 m downstream of 2005) endpoint	Red Blazes	3,330 ft contour line
Kennedy Creek	USFS boundary; 100 m downstream of Rd. 42	No description provided (within 100 m of 2005 and 2015 endpoint)	Stream flows under boulders and rhododendron; impassable	Pool with 70 cm waterfall 4.5 km from start
King Creek	Confluence with Little Piney River	USFS boundary	USFS boundary	USFS boundary
Little Cove Creek	Confluence with North Fork Buffalo River	No description provided (approx. 600 m upstream of 2005 and 2015 endpoint)	No description provided (within 100 m of 2015 endpoint)	Ended at pool with 15 m bedrock slide

Table 2 continued. Summary of descriptive start and end inventory locations.

Stream	Inventory Start Location 1995, 2005, & 2015	Inventory End Location 1995	2005	2015
Love Lady Creek	USFS boundary; at end of bamboo patch	No description provided (2.0 km from start)	Less than 0.5 m wide for required distance	Less than 1 m wide and a riffle for >500 m
Loves Run	USFS boundary; at culvert on Rd. 42	Confluence of two intermittent tributaries	Confluence of two intermittent tributaries	Confluence of two 1.5 m wide tributaries
Maple Creek (lower)	USFS boundary (2005, 2015)	Not inventoried	USFS boundary	USFS boundary
Maple Creek (upper)	USFS boundary (1995)	Habitat too poor to continue	Not inventoried	Not inventoried
North Fork Bennetts Run	Confluence of North and South Fork of Bennetts Run	Two intermittent branches	Channel impassable; no evidence of it coming back	Culvert on Rd. 1154; stream beginning to become unsafe
Pedlar Gap Run	USFS boundary	USFS boundary	USFS boundary	No description provided (2.0 km from start)
Rocky Branch	Confluence with North Fork Buffalo River	No description provided (1.0 km from start)	10 m waterfall, continuous cascade for >150 m, treacherous	Ended after pool with huge boulder/bedrock on right and before steep and long cascade; treacherous

Table 3. GPS coordinates recorded at the downstream (start) and upstream (end) extent of stream habitat inventories. Start location was the same all 3 years; coordinates were recorded in 2015 with Garmin Oregon 450T GPS units. End locations were recorded in 2015 with GPS units and created for 1995 and 2005 with GIS.

	GPS (NAD83)			
	Downstream Inventory	Upstream Inventory End		
Stream	Start: 1995, 2005, 2015	1995	2005	2015
Belle Cove Branch	N37.68440 W79.40959	N37.65357 W79.37414	N37.66041 W79.38384	N37.65837 W79.38382
Big Marys Creek	N37.87747 W79.22253	N37.87254 W79.15548	N37.87316 W79.15063	N37.86815 W79.17440
Coxs Creek	N37.84163 W79.04768	N37.83515 W79.06021	N37.83521 W79.05980	N37.83678 W79.05799
Dancing Creek	N37.61428 W79.30803	N37.63238 W79.33116[A]	N37.63223 W79.33105	N37.62963 W79.32498
Enchanted Creek (lower)	N37.66407 W79.28600	N37.66202 W79.30938	N37.66195 W79.30931	N37.66129 W79.30876
Enchanted Creek (upper)	N37.66527 W79.31420	N37.67348 W79.32808	N37.67356 W79.32575	N37.66904 W79.32031
Greasy Spring Branch	N37.78759 W79.15377	N37.79494 W79.16884	N37.79459 W79.16965	N37.79530 W79.16703
Kennedy Creek	N37.97250 W79.00917	N37.94441 W79.03653	N37.94445 W79.03659	N37.94441 W79.03653
King Creek	N37.75852 W79.12696	N37.77147 W79.12209	N37.77134 W79.12203	N37.77150 W79.12212
Little Cove Creek	N37.72566 W79.19965	N37.73713 W79.20957[B]	N37.73181 W79.20775	N37.73171 W79.20768
Love Lady Creek	N37.62287 W79.28191	N37.62202 W79.30104	N37.62096 W79.30635	N37.62221 W79.31043
Loves Run	N37.98207 W79.08823	N37.96579 W79.09074	N37.96578 W79.09067	N37.96602 W79.09095
Maple Creek (lower)	N37.56942 W79.30905	not inventoried	N37.57581 W79.31243	N37.57586 W79.31227
Maple Creek (upper)	N37.58403 W79.31722	N37.59070 W79.31616[C]	not inventoried	not inventoried
North Fork Bennetts Run	N37.67445 W79.37870	N37.67198 W79.35978	N37.67316 W79.35329	N37.67199 W79.35994
Pedlar Gap Run	N37.71029 W79.35814	N37.69686 W79.33331	N37.69922 W79.33944	N37.70058 W79.34195
Rocky Branch	N37.73028 W79.19524	N37.73885 W79.19724[D]	N37.73946 W79.19753	N37.73272 W79.19632

[A] Dancing Creek had 4.3 km inventoried in 1995, but we used the last 2.6 km for comparison.
[B] Little Cove Creek was inventoried in 1989.
[C] Maple Creek 1995 section is different from 2005 and 2015. The 1995 section is located ~1 km upstream of the of the 2005 and 2015 endpoint.
[D] Rocky Branch was inventoried in 1989.

Table 4. Summary of BVET water depths.

	Mean Average Depth (cm)						Mean Maximum Depth (cm)						Mean Residual		
	Pools			Riffles			Pools			Riffles			Pool Depth (cm)[A]		
Stream Name	1995	2005	2015	1995	2005	2015	1995	2005	2015	1995	2005	2015	1995[B]	2005	2015
Belle Cove Branch	30	28	22	12	14	11	46	41	41	22	29	26	-	18	13
Big Marys Creek	38	32	29	14	15	14	56	50	43	26	30	23	-	23	22
Coxs Creek	35	34	38	15	21	15	58	53	64	29	43	45	-	16	27
Dancing Creek	24	28	23	8	12	10	38	44	46	16	23	32	-	17	18
Enchanted Creek	26	36	38	13	13	21	40	59	64	25	28	44	-	21	24
Greasy Spring Branch	38	31	32	18	19	20	54	46	53	34	34	37	-	15	21
Kennedy Creek	35	38	29	16	15	16	55	62	51	33	29	35	-	25	18
King Creek	31	32	35	15	15	15	44	48	59	26	25	42	-	18	27
Little Cove Creek	38	34	27	20	12	13	59	60	57	34	25	40	-	20	19
Love Lady Creek	27	22	23	10	10	8	41	40	38	19	22	18	-	13	16
Loves Run	26	27	28	12	14	11	36	45	49	21	27	30	-	14	21
Maple Creek[C]	-	25	15	-	9	7	-	39	26	-	28	15	-	28	8
North Fork Bennetts Run	30	39	31	11	13	10	46	55	53	21	32	29	-	28	24
Pedlar Gap Run	26	31	25	12	13	14	38	42	41	20	24	28	-	17	16
Rocky Branch[D]	36	31	-	15	11	-	53	54	-	23	24	-	-	20	-

[A] Residual pool depth = average pool depth - riffle crest depth
[B] Riffle crest depth (used to calculate residual pool depth) was not collected in 1995.
[C] Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded from between-year comparisons.
[D] Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

Table 5. Stream area (m^2 and %) and unit count of pool (i.e. slow water = pool and glide) and riffle (i.e. fast water = riffle, run, and cascade) habitat as observed during BVET habitat inventories.

	Habitat Area (m^2)						Percent Area						Unit Count					
	Pool			Riffle			Pool			Riffle			Pool			Riffle		
Stream Name	1995	2005	2015	1995	2005	2015	1995	2005	2015	1995	2005	2015	1995	2005	2015	1995	2005	2015
Belle Cove Branch	2,613	1,550	1,767	6,992	8,774	8,468	27%	15%	17%	73%	85%	83%	92	74	80	79	72	75
Big Marys Creek	5,437	3,968	4,531	15,694	17,992	10,911	26%	18%	29%	74%	82%	71%	188	89	133	166	88	128
Coxs Creek	2,543	1,031	584	3,015	3,957	3,517	46%	21%	14%	54%	79%	86%	137	43	28	94	42	25
Dancing Creek	4,341	2,433	1,678	6,023	5,417	7,307	42%	31%	19%	58%	69%	81%	112	87	38	98	68	32
Enchanted Creek	4,318	2,217	886	7,036	11,383	11,176	38%	16%	7%	62%	84%	93%	223	70	30	184	72	37
Greasy Spring Branch	833	1,008	470	3,707	6,757	3,311	18%	13%	12%	82%	87%	88%	80	70	28	74	79	29
Kennedy Creek	3,828	3,410	1,719	10,354	11,551	13,479	27%	23%	11%	73%	77%	89%	213	115	66	189	115	67
King Creek	1,129	1,179	437	3,041	4,440	3,423	27%	21%	11%	73%	79%	89%	118	54	24	96	47	24
Little Cove Creek	1,455	1,034	501	3,702	3,205	5,290	28%	24%	9%	72%	76%	91%	81	50	21	79	50	19
Love Lady Creek	2,505	1,824	2,545	2,538	4,670	3,602	50%	28%	41%	50%	72%	59%	68	52	52	58	50	52
Loves Run	1,466	1,056	255	4,770	4,368	4,732	24%	19%	5%	76%	81%	95%	133	48	13	110	43	14
Maple Creek	-[A]	427[B]	478	-[A]	560[B]	1,117	-[A]	43%	30%	-[A]	57%	70%	-[A]	4	21	-[A]	7	22
N. Fork Bennetts Run	1,755	927	941	2,776	4,667	3,458	39%	17%	21%	61%	83%	79%	117	41	29	103	47	29
Pedlar Gap Run	1,614	602	741	3,440	5,273	5,137	32%	10%	13%	68%	90%	87%	134	39	34	116	54	47
Rocky Branch	776	539	-[C]	2,161	2,090	-[C]	26%	21%	-[C]	74%	79%	-[C]	75	39	-[C]	69	47	-[C]

[A] Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded from between-year comparisons. The 1995 section is located ~1 km upstream of the 2005 and 2015 endpoint.
[B] Uncorrected visually estimated wetted stream widths used to calculate habitat area due to lack of measured paired samples.
[C] Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

Table 6. Percent occurrence of dominant substrate size categories in pools (includes glides) in each stream inventoried. Substrate data was not collected in 1995. See appendix A for substrate size categories.

	Pool Dominant Substrate (%)																	
	Organic Matter		Clay		Silt		Sand		Small Gravel		Large Gravel		Cobble		Boulder		Bedrock	
Stream Name	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015
Belle Cove Branch	0	0	0	0	0	0	1	0	7	30	46	26	12	11	1	1	32	31
Big Marys Creek	0	1	0	0	3	0	1	3	61	0	9	43	2	20	0	17	24	17
Coxs Creek	0	0	0	0	2	0	0	0	51	57	7	0	30	0	9	43	0	0
Dancing Creek	1	16	0	0	0	5	2	8	9	0	3	3	14	11	15	16	55	42
Enchanted Creek	1	0	0	0	0	3	6	47	10	7	9	0	9	10	33	30	33	3
Greasy Spring Branch	11	0	0	0	11	0	41	4	31	25	1	43	1	0	0	21	1	7
Kennedy Creek	0	17	0	0	1	0	0	2	7	20	17	12	38	21	27	23	10	6
King Creek	2	0	0	0	0	4	31	0	20	38	0	0	6	13	7	17	33	29
Little Cove Creek	0	5	0	0	0	29	0	5	56	52	4	5	2	0	20	0	18	5
Love Lady Creek	2	2	0	0	0	0	4	6	33	8	6	6	10	40	4	12	42	27
Loves Run	0	46	0	0	0	0	0	0	6	0	23	0	50	31	2	8	19	15
Maple Creek	0	0	0	0	0	0	100	52	0	0	0	0	0	33	0	0	0	14
N. Fork Bennetts Run	0	0	0	0	15	24	10	17	7	21	12	3	2	7	0	3	54	24
Pedlar Gap Run	5	0	0	0	15	0	31	59	31	21	3	15	0	3	10	3	5	0
Rocky Branch	0	-*	0	-*	0	-*	0	-*	41	-*	5	-*	0	-*	13	-*	41	-*

* Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

Table 7. Percent occurrence of subdominant substrate size categories in pools (includes glides) in each stream inventoried. Substrate data was not collected in 1995. See appendix A for substrate size categories.

	Pool Subdominant Substrate (%)																	
	Organic Matter		Clay		Silt		Sand		Small Gravel		Large Gravel		Cobble		Boulder		Bedrock	
Stream Name	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015
Belle Cove Branch	5	1	0	0	0	0	4	0	26	29	23	15	36	28	0	16	5	11
Big Marys Creek	1	0	0	0	13	2	1	0	26	3	28	32	9	32	0	24	21	7
Coxs Creek	2	0	2	0	9	7	2	0	19	29	19	18	28	7	16	39	2	0
Dancing Creek	22	39	0	0	10	3	9	0	21	8	8	13	23	18	6	3	1	16
Enchanted Creek	1	7	0	0	0	0	3	23	14	13	16	13	31	23	27	17	7	3
Greasy Spring Branch	19	0	1	0	51	0	9	0	13	18	6	25	0	21	1	18	0	18
Kennedy Creek	3	26	1	0	0	0	0	2	10	8	11	30	27	21	43	12	4	2
King Creek	4	0	0	0	6	17	19	21	31	29	0	8	6	4	15	13	20	8
Little Cove Creek	2	0	0	0	0	38	0	5	22	14	6	10	2	5	38	19	30	10
Love Lady Creek	15	2	0	0	0	0	4	6	27	37	19	29	19	12	8	10	8	6
Loves Run	6	23	0	0	0	0	2	0	17	8	21	15	21	31	33	8	0	15
Maple Creek	0	0	0	0	100	0	0	29	0	43	0	10	0	10	0	0	0	10
N. Fork Bennetts Run	2	0	0	0	24	3	12	41	34	31	15	3	10	3	0	3	2	14
Pedlar Gap Run	3	3	0	0	10	0	13	12	44	21	8	24	18	15	5	26	0	0
Rocky Branch	0	-*	3	-*	3	-*	0	-*	32	-*	3	-*	3	-*	32	-*	26	-*

* Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

Table 8. Percent occurrence of dominant substrate size categories in riffles (includes cascades and runs) in each stream inventoried. Substrate data was not collected in 1995. See appendix A for substrate size categories.

	Riffle Dominant Substrate (%)																	
	Organic Matter		Clay		Silt		Sand		Small Gravel		Large Gravel		Cobble		Boulder		Bedrock	
Stream Name	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015
Belle Cove Branch	0	0	0	0	0	0	0	0	11	16	57	28	11	17	1	13	19	25
Big Marys Creek	0	0	0	0	0	0	0	0	41	0	25	5	15	29	0	51	19	16
Coxs Creek	0	0	0	0	0	0	0	0	7	0	5	4	33	0	52	96	2	0
Dancing Creek	0	0	0	0	0	0	0	3	25	6	4	6	25	47	9	16	37	22
Enchanted Creek	0	0	0	0	0	0	0	0	1	8	4	0	28	22	53	62	14	8
Greasy Spring Branch	6	0	0	0	0	0	0	0	9	0	25	3	23	14	14	69	23	14
Kennedy Creek	0	3	0	0	0	0	0	0	0	10	2	13	41	33	47	34	10	6
King Creek	0	0	0	0	0	0	0	0	6	13	0	0	23	67	26	13	45	8
Little Cove Creek	0	0	0	0	0	0	0	0	0	0	2	0	0	0	59	63	39	37
Love Lady Creek	0	0	0	0	0	0	0	0	14	0	16	27	42	62	12	0	16	12
Loves Run	0	0	0	0	0	0	0	0	2	0	23	7	60	79	7	0	7	14
Maple Creek	0	0	0	0	0	0	100	0	0	5	0	0	0	91	0	0	0	5
N. Fork Bennetts Run	0	0	0	0	0	0	2	0	6	0	13	7	38	17	4	48	36	28
Pedlar Gap Run	0	0	0	0	0	0	4	2	35	22	11	37	33	11	4	22	13	7
Rocky Branch	0	-*	0	-*	0	-*	0	-*	4	-*	2	-*	0	-*	50	-*	43	-*

* Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

Table 9. Percent occurrence of subdominant substrate size categories in riffles (includes cascades and runs) in each stream inventoried. Substrate data was not collected in 1995. See appendix A for substrate size categories.

	Riffle Subdominant Substrate (%)																	
	Organic Matter		Clay		Silt		Sand		Small Gravel		Large Gravel		Cobble		Boulder		Bedrock	
Stream Name	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015	2005	2015
Belle Cove Branch	0	0	0	0	0	0	0	0	14	17	21	20	58	28	0	29	7	5
Big Marys Creek	0	0	0	0	0	0	1	2	44	0	36	15	13	46	2	34	3	3
Coxs Creek	0	0	0	0	2	0	0	0	21	32	14	0	50	64	12	4	0	0
Dancing Creek	6	0	0	0	3	0	6	3	35	22	12	22	35	25	3	25	0	3
Enchanted Creek	0	0	0	0	0	0	1	5	3	16	8	14	47	41	29	16	11	8
Greasy Spring Branch	6	0	0	0	0	0	1	0	9	3	10	10	35	38	34	31	4	17
Kennedy Creek	2	0	0	0	0	0	0	1	3	13	9	27	45	27	40	31	2	0
King Creek	0	0	0	0	0	0	0	0	43	50	0	33	21	8	28	0	9	8
Little Cove Creek	10	11	0	0	0	0	0	0	16	53	6	0	28	5	32	26	8	5
Love Lady Creek	0	0	0	0	0	0	2	0	14	52	40	38	34	10	4	0	6	0
Loves Run	0	0	0	0	0	0	0	0	5	21	26	50	33	14	37	7	0	7
Maple Creek	0	0	0	0	57	0	0	0	29	64	14	27	0	9	0	0	0	0
N. Fork Bennetts Run	9	10	0	0	4	7	6	0	28	7	32	3	17	31	0	31	4	10
Pedlar Gap Run	2	2	0	0	2	0	7	2	43	28	19	46	22	15	6	7	0	0
Rocky Branch	21	-*	0	-*	0	-*	0	-*	43	-*	0	-*	6	-*	17	-*	13	-*

* Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

Table 10. Summary of BVET stream habitat wetted widths and percent fines.

	Average Wetted Width (m)						Average Percent Fines					
	Pools			Riffles			Pools			Riffles		
Stream Name	1995	2005	2015	1995	2005	2015	1995[A]	2005	2015	1995[A]	2005	2015
Belle Cove Branch	3.1	2.8	3.0	2.3	2.6	3.0	-	15	6	-	9	5
Big Marys Creek	3.4	3.9	3.5	3.6	3.9	2.6	-	18	11	-	11	7
Coxs Creek	3.3	5.1	3.7	3.1	4.4	3.7	-	14	29	-	9	13
Dancing Creek	3.2	3.2	3.6	3.3	3.2	3.4	-	29	23	-	11	18
Enchanted Creek	3.8	4.1	4.2	3.5	4.9	3.9	-	21	51	-	9	20
Greasy Spring Branch	2.3	3.4	2.8	2.4	4.4	2.5	-	50	15	-	8	7
Kennedy Creek	2.9	3.2	3.2	2.8	3.3	3.3	-	13	15	-	6	11
King Creek	2.4	4.0	3.3	2.2	3.1	2.4	-	35	25	-	7	6
Little Cove Creek	3.8	3.7	4.2	5.2	3.4	4.8	-	17	44	-	6	13
Love Lady Creek	0.5	3.1	2.9	0.9	3.0	2.8	-	21	18	-	10	7
Loves Run	2.1	3.0	2.9	2.5	2.4	2.2	-	17	18	-	7	10
Maple Creek[B]	-	2.1[C]	1.8	-	2.1[C]	1.9	-	90	54	-	88	16
North Fork Bennetts Run	2.9	3.7	4.1	2.2	3.3	2.1	-	37	49	-	20	12
Pedlar Gap Run	2.4	2.7	2.9	2.2	3.2	2.7	-	49	49	-	19	22
Rocky Branch[D]	2.8	3.0	-	3.3	2.4	-	-	21	-	-	9	-

[A] Percent fines data was not collected in 1995.
[B] Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded from between-year comparisons.
[C] Uncorrected visually estimated wetted stream widths used to calculate average wetted width due to lack of measured paired samples.
[D] Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

Table 11. Large wood (LW) per kilometer observed during BVET habitat inventories. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter (rootwads were not tallied in 1995 and are not presented for 2005 and 2015). Hemlock LW/km is the quantity of LW/km (all size classes) identifiable as hemlock (only collected in 2015; values in parenthesis show difference when total inventory length is used rather than comparison inventory length).

	Large Wood per Km															
	LW1/ km			LW2/km			LW3/km			LW4/km			Total LW/km			Hemlock LW/km
Stream Name	1995	2005	2015	1995	2005	2015	1995	2005	2015	1995	2005	2015	1995	2005	2015	2015
Belle Cove Branch	80	12	41	19	0	0	201	27	28	24	1	0	324	39	69	0 (1)
Big Marys Creek	7	6	84	3	0	3	3	35	81	3	2	4	15	43	172	84
Coxs Creek	71	4	38	4	0	1	13	41	57	2	0	4	91	45	100	8
Dancing Creek	50	19	65	4	1	0	29	44	45	12	8	2	96	72	112	8
Enchanted Creek	67	34	98	14	0	1	39	48	70	8	21	2	128	104	172	71
Greasy Spring Branch	41	25	147	14	20	1	94	108	97	34	25	6	183	178	251	73
Kennedy Creek	15	5	29	2	0	0	15	12	29	5	1	1	38	18	58	0
King Creek	26	14	31	2	0	0	41	41	31	2	1	3	72	56	65	9
Little Cove Creek	71	10	77	4	2	0	24	43	43	4	16	3	102	71	123	0
Love Lady Creek	24	12	53	2	0	0	20	14	23	4	3	0	49	30	76	9 (18)
Loves Run	21	13	75	1	0	1	9	44	83	0	5	2	32	62	161	1
Maple Creek	-[A]	8	35	-[A]	0	0	-[A]	18	24	-[A]	0	0	-[A]	27	59	13
N. Fork Bennetts Run	122	9	59	13	13	1	144	46	38	42	6	4	320	73	102	54
Pedlar Gap Run	20	21	25	0	0	0	18	10	35	4	1	0	43	32	60	0
Rocky Branch	33	0	-[B]	11	9	-[B]	20	49	-[B]	14	9	-[B]	78	67	-[B]	0

[A] Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded from between-year comparisons. The 1995 section is located ~1 km upstream of the 2005 and 2015 endpoint.

[B] Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

Table 12. Large wood (LW) count observed during BVET habitat inventories. LW size classes: LW1 = 1-5 m length, 10-55 cm diameter; LW2 = 1-5 m length, >55 cm diameter; LW3 = >5 m length, 10-55 cm diameter; LW4 = >5 m length, >55 cm diameter (rootwads were not tallied in 1995 and are not presented for 2005 and 2015). Hemlock LW n is the quantity of LW (all size classes) identifiable as hemlock (only collected in 2015; values in parenthesis show difference when total inventory length is used rather than comparison inventory length).

	Large Wood Count in Sample Reach															
	LW1 n			LW2 n			LW3 n			LW4 n			Total LW n			Hemlock LW n
Stream Name	1995	2005	2015	1995	2005	2015	1995	2005	2015	1995	2005	2015	1995	2005	2015	2015
Belle Cove Branch	332	47	165	79	1	0	838	107	113	102	3	0	1,351	158	278	0 (6)
Big Marys Creek	38	34	457	15	1	14	17	189	437	14	11	23	84	235	931	453
Coxs Creek	115	5	44	7	0	1	21	50	66	4	0	5	147	55	116	9
Dancing Creek	146	51	166	13	2	1	84	117	116	35	20	4	278	190	287	20
Enchanted Creek	202	98	308	43	0	4	119	138	219	24	61	7	388	297	538	224
Greasy Spring Branch	75	48	230	25	39	1	174	209	152	63	48	9	337	344	392	114
Kennedy Creek	66	21	130	8	0	0	67	54	131	23	4	3	164	79	264	1
King Creek	46	24	53	4	0	0	72	68	52	4	1	5	126	93	110	15
Little Cove Creek	80	12	85	5	2	0	27	51	47	4	19	3	116	84	135	0
Love Lady Creek	48	25	113	4	0	1	39	29	50	7	7	0	98	61	164	19 (52)
Loves Run	53	29	176	3	0	3	22	100	195	1	11	4	79	140	378	2
Maple Creek	-[A]	5	30	-[A]	0	0	-[A]	11	20	-[A]	0	0	-[A]	16	50	11
N. Fork Bennetts Run	224	16	106	23	23	2	263	82	68	76	11	8	586	132	184	98
Pedlar Gap Run	42	39	51	1	0	0	39	19	71	9	2	0	91	60	122	1
Rocky Branch	34	0	-[B]	11	9	-[B]	21	49	-[B]	14	9	-[B]	80	67	-[B]	0

[A] Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded from between-year comparisons. The 1995 section is located ~1 km upstream of the 2005 and 2015 endpoint.

[B] Rocky Branch 2015 inventory ended early due to waterfall and cascade conditions too dangerous to proceed. The inventory is excluded from between-year comparisons due to lack of data.

Appendix A: Field methods for stream habitat inventory

Guide to Stream Habitat Characterization using the BVET Methodology in the George Washington Jefferson National Forest, VA

Prepared by:

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2015

Table of Contents

Introduction

The basinwide visual estimation technique (BVET) is a versatile tool used to assess streamwide habitat conditions in wadeable size streams and rivers. A crew of two individuals performs the inventory using two-stage visual estimation techniques described in Hankin and Reeves (1988) and Dolloff et al. (1993). In its most basic form the BVET combines visual estimates with actual measurements to provide a calibrated estimate of stream area with confidence intervals, however the crew may inventory any number of other habitat attributes as they walk length of the stream. Experienced crews can inventory an average of 2.0 – 3.0 km per day, but this will vary depending on stream size and the number of stream attributes inventoried.

Before a crew begins a BVET inventory they must receive adequate training, both in the classroom and in the field. Estimating and measuring a large number of habitat attributes can confuse and overwhelm an inexperienced crew. Individuals must have an understanding of the basic concepts behind the BVET and be familiar with habitat attributes before they can effectively and efficiently perform an inventory.

The USFS Center for Aquatic Technology Transfer (CATT) has been working directly with resource managers on the George Washington Jefferson National Forest (GWJNF) since the mid 1990's to implement BVET inventories and adapt them to the Forest's specific needs. More than 10 habitat attributes are currently estimated or measured during GWJNF BVET habitat inventories. We review the inventory annually and add and remove attributes as needed to maximize efficiency and relevancy with regards to emerging techniques and Forest issues. Changes are made only after careful review to ensure consistency with data collected in the past. Changes to the survey are described in the 'Changes to BVET inventory in 2015' section.

This document was developed to serve as a guide for classroom and field instruction specific to the GWJNF BVET habitat inventory and to provide a post-training reference for field crews. It includes an overview of the BVET inventory, defines habitat attributes, instructs how and when to measure attributes, and provides reference sheets for use in the field. Each trainee should receive a copy of this manual and is encouraged to take notes in the spaces provided.

References cited in this manual:

Armantrout, N. B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.

Dolloff, C. A., D. G. Hankin, and G. H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. General Technical Report SE-83. Asheville, North Carolina: U.S. Department of Agriculture, Southeastern Forest Experimental Station.

Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:834-844.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, Colorado.

Rosgen, D.L., and L. Silvey. 1998 Field Guide for Stream Classification, Wildland Hydrology Books, Pagosa Springs, Colorado.

Changes to BVET inventory in 2015

Attribute	Action	Reason
Hemlock LW	added	Quantify hemlock LW in bankfull channel
Hemlock Condition	Added	Assess riparian hemlock condition
Hemlock Abundance	Added	Assess riparian hemlock abundance
Rosgen	Removed	Rosgen classification collected in prior inventories

Other minor changes, mostly modifications in terminology and definitions to provide increased clarity, are found throughout the manual.

Outline of BVET Habitat Inventory

The inventory is comprised of the following steps:

1) Enter 'header' information in the data sheet
    - 'Header' information includes date, stream, start location, crew, etc. and is **vitally** important to record for future reference

2) Select an appropriate measurement interval and a random number
    - In streams < 1.0 km measure every 5th unit (random number 1-5), in streams > 1.0 km measure every 10th unit (random number 1-10)
    - The random number designates the first habitat unit (i.e. the paired sample unit) in which the crew will perform measurements

3) Enter downstream of the starting point, then move upstream and begin the inventory
    - Tie off the hipchain, proceed upstream to the starting point, reset the hipchain to zero, and proceed upstream estimating parameters and recording data in every habitat unit

4) At the paired sample unit perform visual estimates, then perform measurements
    - If the random number '3' were chosen, the crew would stop after making estimates in the 3rd pool (and 3rd riffle) and perform the necessary measurements

5) Progress upstream estimating attributes for every unit until the next paired sample unit is reached, then repeat step 4
    - In the above example, if the interval were 10 units, the crew would stop at the 13th, 23rd, 33rd, etc. pool (and 13th, 23rd, 33rd, etc. riffle) and repeat measurements done in pool 3 and riffle 3.
    - The crew should also take care to record roads, trails, tributaries, dams, waterfalls, road crossing types, riparian features (wildlife openings, trails, campsites, roads, timber harvest, etc.), and other pertinent stream features as they progress upstream. Be sure to record hipchain distances when noting such features.

Repeat steps 4 and 5 until the end of inventory reach.

The following sections describe the BVET habitat inventory in detail:

Section 1: Getting Started – equipment lists, header information, random numbers, starting the inventory

Section 2: Habitat Attributes – definitions, how to estimate or measure, when to record

Section 3: Wrapping Up – what to do when the inventory is completed

Appendix: field guide, random number tables, equipment checklist

Section 1: Getting Started

Equipment List

Hipchain & extra string	Backpack
wading rod	Pencils
50 m tape measure	Flagging
Datalogger	Markers
GPS unit	waterproof backup datasheets
topographic map	BVET manual and field guide
camera	felt bottom wading boots or waders
Clinometer (for cascades)	Water Filter
Thermometer	1st Aid Kit & toilet paper

Other useful equipment: lunch, water, rain gear, radio/cell phone

The crew consists of two individuals, the 'observer' and the 'recorder'. The observer wears the hipchain and carries the wading rod. The recorder wears the data logger and carries other equipment in the backpack. The duties of each individual are listed below.

Duties

Observer	**Recorder**
Designate habitat units	Record data
Measure distance	Determine paired sample location
Estimate width	Classify and count LW
Estimate depths	Hemlock LW, abundance, condition
Classify substrates	Photo-documentation
Estimate percent fines	Document features

Both crew members are needed to measure actual widths, channel widths, riparian areas, gradient, and water temperature at designated units. Although the crew has assigned duties, they should not hesitate to consult with each other if they have questions or feel that a mistake may have been made. Working as a team will provide the best possible results.

Header Information

Header information is **vitally important** for future reference. Take the time to record all categories completely and accurately.

Stream Name	Full name of stream
District	National Forest District name
Quad	USGS 1:24,000 quadrangle name
Date	Record date(s) of inventory
Recorder	Full name of recorder
Observer	Full name of observer
GPS	record at start and end locations, always use NAD27 CONUS, UTM
Location	**Detailed** written description of start point, include landmarks, road #, etc.
Notes	Record signs of activity in area, water conditions, other pertinent information

Random Numbers

Before beginning the inventory, select a number from a random numbers table (see Appendix) to determine the first habitat unit at which to make measurements. For long inventories (> 1.0 km) select a random number between 1 and 10th (i.e. measure every 10 unit), for shorter streams use a number between 1 and 5 (i.e. measure every 5th unit). See the appendix for random numbers tables.

The crew needs to measure units more frequently during shorter inventories to provide enough 'paired samples' for data analysis. 'Paired samples' are habitat units in which both visual estimates and actual measurements are made. The more paired samples, the tighter the confidence intervals for stream area estimates.

After the crew records a paired sample they continue upstream making visual estimates and stopping to make additional measurements at the pre-determined interval. For example, if the random number was 3 and the crew was measuring every 5th unit, the crew would make measurements on the 3rd pool and 3rd riffle and then every 5th pool and riffle thereafter (8, 13, 18, 23, etc).

Starting the Inventory

After the crew has organized their gear, determined their measurement interval, selected a random number, recorded all the header information, and determined the start location they are ready to begin the habitat inventory. The observer should enter the stream slightly downstream of the starting point, tie off the hipchain, progress upstream to the starting point, reset the hipchain to zero and begin walking upstream through the first habitat unit. As the observer moves upstream they use the wading rod to measure depth at several locations in the habitat unit and make observations of unit type, width, substrates, and percent fines. When they reach the upstream end of the habitat unit they stop, report the distance, then turn to face the unit and report the unit type, estimated width, maximum and average depth, riffle crest depth (where appropriate), dominant and subdominant substrate classes, and percent fines to the recorder.

As the observer moves upstream through the unit, the recorder follows behind, recording the amount of LW in the habitat unit. The recorder also assigns a number to the habitat unit. The recorder tells the observer if a unit is designated for measurements (i.e. if it is a 'paired sample' unit) only after they have recorded visual estimates.

The crew continues upstream making estimates in every habitat unit and making estimates and measurements in every paired sample unit until the inventory endpoint is reached.

Definitions of habitat attributes, how to measure and when to record them, and what to do when the inventory is complete are covered in the following sections.

Section 2: Stream Attributes

Unit Type (see abbreviations)

Definitions:*

Unit Type	Abbreviation	Definition
Riffle	**R**	**Fast water, turbulent, gradient <12%**; shallow reaches characterized by water flowing over or around rough bed materials that break the surface during low flows; also **include rapids** (turbulent with intermittent whitewater, breaking waves, and exposed boulders), **chutes** (rapidly flowing water within narrow, steep slots of bedrock), and **sheets** (shallow water flowing over bedrock) if gradient <12%
Cascade	**C**	**Fast water, turbulent, gradient ≥12%**; highly turbulent series of short falls and small scour basins, with very rapid water movement; also **include sheets** (shallow water flowing over bedrock) and **chutes** (rapidly flowing water within narrow, steep slots of bedrock) if gradient ≥12%
Run	**RN**	**Fast water, non-turbulent, gradient <12%**; deeper than riffles with little or no surface agitation or flow obstructions and a flat bottom profile
Pool	**P**	**Slow water, surface turbulence may or may not be present, gradient <1%**; generally deeper and wider than habitat immediately upstream and downstream, concave bottom profile; **includes dammed pools, scour pools, and plunge pools**
Glide	**G**	**Slow water, no surface turbulence, gradient <1%**; shallow with little to no flow and flat bottom profile
Underground	**UNGR**	Stream channel is dry or not containing enough water to form distinguishable habitat units

*modified from Armantrout (1998)

How to estimate:
Habitat units are separated by 'breaks'. Breaks can be obvious physical barriers, such as a debris dam separating two pools or a small waterfall separating a pool and riffle, or may be less obvious transitional areas. Questions often arise as to whether a break is substantial enough to split two habitat units and where the exact location of the break occurs. When in doubt, the observer should consult with the recorder and the team should 'think like a fish'. To determine if a break should be made, consider whether a fish would have to make an effort to move across the break and into the next habitat unit. If not, then it is probably a single habitat unit.

The channel may have both pool and riffle type habitat in the same cross-sectional area. Determine the predominate habitat type and record it as the unit type. For example if an area contains both pool and riffle, but the majority of the flow is into and out of the pool habitat, then call a pool.

Questions also often arise as to the minimum size of individual habitat units. Generally, if a habitat unit is not at least as long as the wetted channel is wide, then do not count it as a separate habitat unit. This rule may need to be adjusted for streams wider than 5 m. Use best professional judgment in such cases.

See the section 2.1 for a list of features that should also be recorded while performing the inventory.

When to record: every habitat unit

Unit Number (#)

Definition:
Count of habitat units of similar types, used to determine location of paired sample units

How to estimate:
When counting habitat units, group pools and glides (slow water) together, and group riffles, runs, and cascades (fast water) together. For example, consider the following sequence of habitat units:

Pool – Riffle – Pool – Pool – Riffle - Cascade – Riffle - Glide – Riffle – Pool – Run – Pool – Riffle

Habitat units in this sequence would be counted in the following manner (similar types are shaded same color):

Unit Type	Unit Number
P	1
R	1
P	2
P	3
R	2
C	3
R	4
G	4
R	5
P	5
RN	6
P	6
R	7

In the above example, the crew has counted six slow water (pool/glide) units and seven fast water (riffle/run/cascade) units.

If '3' were chosen as the random number and the measuring interval was every 10th unit, the crew would estimate and then measure habitat data for Pool 3 and Cascade 3 (i.e. Pool 3 and Cascade 3 are 'paired sample' units). When the crew reaches pool or glide 13 and riffle, run, or cascade 13, they would repeat procedures followed in the 3rd units.

When to record: every habitat unit; not recorded for features such as falls, tributaries, side channels, culverts, etc.

Distance (m)

Definition:
Number of meters from the start of the inventory to the upstream end of the habitat unit or distance from the start of the inventory to upstream end of a feature, used as spatial reference for data analysis and to locate features in the future.

How to estimate:
The observer walks upstream in the middle of the stream channel with a hipchain measuring device. When they reach the upstream break between habitat units or the upstream end of a feature they stop and report the distance to the recorder.

Care should be taken to keep the hipchain string in the middle of the stream, especially around bends and meanders. If the hipchain should break, retreat to the location where the break occurred, tie off the hipchain, and continue. If the hipchain is reset for any reason be sure to note it in the comments.

When to record: every habitat unit and feature

Estimated Width (m)

Definition:
Average wetted width of the habitat unit as estimated visually, used to calculate stream area. Wetted width is the distance from the edge of the water on one side of the main channel to the edge of the water on the opposite side of the main channel.

How to estimate:
The observer notes the general shape and width of the unit while walking to the upstream end. When they reach the upstream end of the unit the observer stops, turns to face the unit, and estimates the average wetted width. Measure the wetted width of the stream before starting each day to calibrate yourself.

When to record: every habitat unit

Maximum and Average Depth (cm)

Definitions:
Maximum Depth – vertical distance from substrate to water surface at deepest point in habitat unit
Average Depth – average vertical distance from substrate to water surface in habitat unit

How to estimate:
The observer uses a wading rod marked in 5 cm increments to measure water depth as they walk upstream through the habitat unit. Water depth in deepest spot is recorded as the maximum depth. Average depth is the average of several depth measurements taken throughout the habitat unit.

When to record: every habitat unit

Riffle Crest Depth (cm)

Definition:
Vertical distance from the substrate to the water surface at the deepest point in the riffle crest. The riffle crest is the shallowest continuous line (usually not straight) across the channel where the water surface becomes continuously riffled in the transition area between a riffle (or a run or cascade) and a pool (or glide) (Armantrout 1998); think of it as the last place water would flow out of the pool if the riffle ran dry.

How to estimate:
When the observer reaches the upstream end of a riffle (or a run or cascade) leading into a pool (or glide), they use the wading rod to measure the deepest point in the riffle crest. Record the depth in the RCD column for the riffle habitat row.

When to record: at the upstream end of any riffle, run, or cascade leading into a pool or glide; also record RCD where short riffles break pools

Dominant and Subdominant Substrate (1-9)

Definitions:
Dominant Substrate: size class of stream bed material that covers the greatest amount of surface area within the wetted channel of the habitat unit
Subdominant Substrate: size class of stream bed material that covers the 2nd greatest amount of surface area within the wetted channel of the habitat unit

How to estimate:
The following size classes are used to categorize substrates*. The substrate 'Number' is entered into the dominant and subdominant substrate columns on the datasheet.

Type	Number	Size (mm)	Description
Organic Matter	1		dead leaves, detritus, etc. – **not live plants**
Clay	2		sticky, holds form when rolled into a ball
Silt	3		slippery, does not hold form when rolled into a ball
Sand	4	silt – 2	grainy, does not hold form when rolled into ball
Small Gravel	5	3-16	sand to thumbnail
Large Gravel	6	17-64	thumbnail to fist
Cobble	7	65-256	fist to head
Boulder	8	>256	larger than head
Bedrock	9		solid rock, parent material, may extend into bank

** these size classes are based on the modified Wentworth scale*

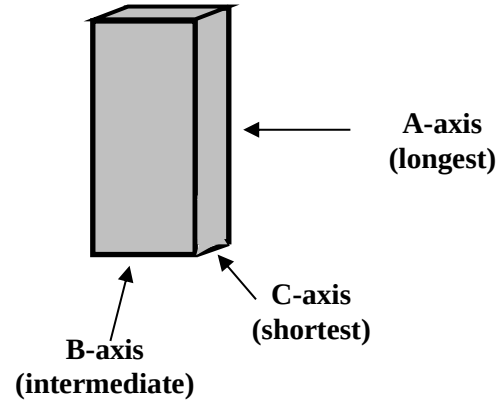
As the observer walks through the unit they scan the substrate. When they reach the upstream end of the unit they stop, turn to face the unit, and determine the dominant and subdominant substrate classes.

Estimate substrate size along the intermediate axis (b-axis). The b-axis is not the longest or shortest axis, but the intermediate length axis (see below). It is the axis that determines what size sieve the particle could pass through. Remember that your eyes are naturally drawn to larger size substrates. Be careful not to bias your estimate by focusing on the large size substrate.

Some units will contain a mixture of particle sizes. Consult with the recorder and use your best professional judgment to choose the dominant and subdominant sizes.

In units where the substrate is covered in moss, algae, or macrophytes classify the underlying substrate and make note of the plant growth in the comments. Only call organic substrate where there is dead and down leaves or other detritus covering the bottom of the unit.

When to record: every habitat unit



Percent Fines (%)

Definition:
Percent of the total surface area of the stream bed in the wetted area of the habitat unit that consists of sand, silt, or clay substrate particles (i.e. particles < 2 mm diameter).

How to estimate:
As the observer walks through the habitat unit they note the amount of sand, silt, and clay in the habitat unit. When they reach the upstream end of the unit, they stop, turn to face the unit and estimate the amount of the total surface area within the wetted channel that consists of sand, silt, or clay.

Where to estimate: every habitat unit

Large Wood (1-4 and rootwad)

Definition:
Count of dead and down wood within the bankfull channel of a habitat unit

How to estimate:
The recorder classifies and counts LW as they walk through the habitat unit. LW counts are grouped by the size classes listed below:

Category	Length (m)	Diameter (cm)	Description
1	1-5	10-55	short, skinny
2	1-5	>55	short, fat
3	>5	10-55	long, skinny
4	>5	>55	long, fat
RW	rootwad	rootwad	roots on dead and down tree

Only count large wood that is:
- > 1.0 m in length and > 10.0 cm in diameter
- within the bankfull channel
- fallen, not standing dead

- Count rootwads separately from attached pieces of LW
- Estimate the diameter of LW at the widest end of the piece
- A piece that is forked, but is still joined counts as only one piece of LW
- Only count each piece one time, do not count a piece that is in two habitat units twice
- Enter the total count for each size category into the appropriate column on the datasheet

Where to estimate: every habitat unit

Hemlock Large Wood

Definition:
Count of dead and down wood within the bankfull channel of a habitat unit that is identifiable as hemlock (Hemlock LW is already counted in LW Data; this is a separate count of only Hemlock LW, all size classes combined).

How to estimate:
The recorder counts a total tally of all LW that is identifiable as hemlock as they walk through the habitat unit. Only count hemlock large wood that is > 1.0 m in length and > 10.0 cm in diameter, within the bankfull channel, and fallen, not standing dead.

Actual Width (m)

Definition:
Average wetted width of the habitat unit as measured with 50 m tape, used to calculate stream area. Wetted width is the distance from the edge of the water on one side of the main channel to the edge of the water on the opposite side of the main channel.

How to measure:
Use a meter tape to measure the wetted width of the stream in at least three locations. Average the measurements to obtain the average wetted width.

Where to measure: paired sample habitat units

Hemlock Condition

Definition:
Visual estimate of the condition of standing hemlock trees (DBH >10 cm) in the riparian zone (water's edge to 30 m up the streambank; visually estimated) as you walk between paired fast-water units. For the first paired sample, the condition of riparian hemlocks is since the start of the inventory.

How to measure:
Observe the general condition of hemlocks in the riparian area as you walk between paired sample units. Select from one of the following categories for hemlock condition:

Category	Description	Wooly needles	Needle loss	Limb loss
Healthy/Light Infestation (1)	Healthy or early stages of infestation	None to some	0-25%	Rare
Infested (2)	Late stages of infestation	Yes	25 – 75%	Small, medium branches
Dead (3)	Mortality; majority of hemlocks are dead	Yes for the few remaining needles	> 75%	Small, medium, large branches and tree tops

Where to measure: assess throughout reach, but record only at paired fast-water units

Hemlock Abundance

Definition:
Category describing the total number of hemlocks encountered since the last paired fast-water unit.

How to measure:
Estimate the number of standing hemlock trees (live or dead with DBH >10 cm) in the riparian zone (water's edge to 30 m up the streambank; visually estimated) as you walk between paired fast-water units.

Select from one of the following categories for hemlock abundance:
None (1) = no hemlocks; **Few (2)** = 1-10; **Some (3)** = 11-50; **Many (4)** = >50 hemlocks

Where to measure: do counts throughout reach but record only at paired sample habitat units

Photo #

Definition:
Photograph of habitat unit or crossing feature.

How to measure:
Take photo facing upstream with observer holding wading rod in picture. Be sure to get entire width (and length if possible) of habitat unit or crossing feature in the photo. Record photo number shown on digital camera.

Where to measure: paired sample riffles, runs, or cascades and any crossing features encountered

GPS (ID)

Definition:
Name of the point recorded to mark a waterfall, crossing feature or other location in the GPS unit.

How to measure:
Stand as close to the feature as possible and allow the GPS to have a clear view of the sky. Mark a waypoint on the GPS, then edit the waypoint name as follows:

S##	**Start** location of BVET survey
P##	**Pause** location of BVET survey if survey is not completed that day
T##	**Tributary** with name shown on quad map
E##	**End** location of BVET survey when survey is completed
W##b	**Waterfall**
B##b	**Bridge**
Fd##b	**Ford**
D##b	**Dam**
V##b	**Culvert**
O##b	**Other**, enter a brief description into the note section for the waypoint

= stream priority number – see stream list or map
b = use b, c, d, etc to create unique labels when more than 1 of a feature type are encountered on a stream; for example if 3 waterfalls are found on stream priority number 5 the first waterfall would be W5, the second would be W5b, the third W5c

Where to measure: all waterfalls, all crossing features, any other notable features encountered during the survey that we may want to locate in the future or that could serve as landmarks

See Section 5 below for additional information on GPS use.

Features

Definition: points on a stream that could potentially serve as landmarks, may be natural or manmade

How to measure: record the distance to the upstream end of a feature; record distance of **all features** (both stream and crossing features) in the regular habitat datasheet; also record additional measurements for crossing features in the crossing datasheet and take a photograph of all crossing features

Where to record: wherever found

Channel Feature	Abbreviation	What to Record
Waterfall[1]	**FALL**	Distance, estimated height
Tributary	**TRIB**	Distance, average wetted width, into main channel on left or right (as facing upstream)
Side channel[2]	**SCH**	Distance, average wetted width, whether it is flowing into or out of main channel on left or right (as facing upstream)
Braid[3]	**BRD**	Distance at start and distance at end; continue with normal inventory up channel with greatest discharge
Seep (Spring)	**SEEP**	Distance, left or right bank (as facing upstream), size, coloration
Landslide	**SLID**	Distance, left or right bank (as facing upstream), estimated size
Other	**OTR**	Distance, description of feature, *example:* found water intake pipe going to house here; old burned out shack on side of stream; Big Gap campground on left; alligator slide here, etc.

1 must be vertical with water falling through air to be a waterfall and not a cascade, do not record unless >1m high
2 two channels, continue with normal inventory up channel with most volume
3 three or more channels intertwined, continue with normal inventory up channel with most volume

Crossing Feature	Abbreviation	What to Record*
Bridge	**BRG**	Distance, width, height, road or trail name and type (gravel, paved, dirt, horse, ATV, etc.), photo
Ford	**FORD**	Distance, road or trail name and type (gravel, paved, dirt, etc.), photo
Dam	**DAM**	Distance, type, condition, estimated height, dam use, name of road or trail, if applicable; include beaver dams, photo
Culvert	**V**	Distance, road or trail name, type, # of outlets, diameter/width, height, material, perch (distance from top of water to bottom lip of culvert, natural substrate (present or absent through length), photo

* photograph all crossing features with person and wading rod for scale, record 'Y' in 'Photo' column

We cannot stress enough the importance of fully and accurately describing features. This means getting out a quadrangle map and finding road, trail, and tributary names and recording them in 'Comments' and taking the time to describe the location of features in relation to landmarks found on quadrangle maps.

Take photos of all crossing features and waterfalls!
Take GPS of all waterfalls!

Section 3: Wrapping Up

End the inventory where previous inventory ended or:

- Forest Service property ends
- Stream is dry for more than 500 m
- Stream channel is < 1.0 m wide for more than 500 m

Record the following in the Comments:

- Time and date
- Reason for ending the inventory
- Detailed written description of location using landmarks for reference
- **Be sure the header information is completed – GPS, etc**

When you return to home base:

- Immediately download the data and check file to be sure all data downloaded
- Check header information to be sure it is complete
- Save to the computer and create a backup copy
- Document any photographs
- If using paper, make a photocopy of the data and store in secure location

Section 4: Summary

Before starting:

- fill in header information

Record for every habitat unit:

- Unit Type
- Unit Number
- Distance
- Estimated Width
- Maximum Depth
- Average Depth
- Dominant Substrate
- Subdominant Substrate
- Percent Fines
- Large Wood and Hemlock LW

Record for every riffle, run, or cascade (including breaks) leading into a pool or glide:

- Riffle Crest Depth

Record for every paired sample pool:

- Measured Width

Record for every paired sample riffle:

- Measured Width
- Hemlock Condition and Abundance
- Photograph
- Water Temperature

Record features and full feature descriptions wherever they are encountered.

Photograph all crossings!

Section 5: GPS Instructions

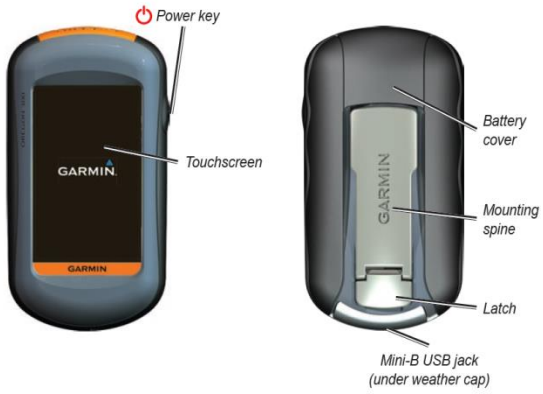
How to Find a Waypoint on GPS:

- Turn Power On.
- On the main menu screen touch the **Where To?** icon with the magnifying glass.
- Touch the **Waypoints** icon with the red golf flag.
- At the bottom of the next screen touch the **ABC** pyramid button.
- Start typing in the name of the desired waypoint. Once the waypoint name is identified by the GPS it will list the waypoints associated with that waypoint name.
    - Note: Touch the left and right arrows at the bottom of the screen to move from letters to numbers to symbols. Touch the down arrow on the letters to get lowercase and up arrow to get back to uppercase.
- Touch the waypoint name you were looking for when the list pops up.
- To navigate to this location touch the big green **Go** button.

Changing Waypoints:

- To switch waypoints close the map screen by touching the **X** close button in the lower left corner of the screen.
- On the main menu screen touch the **Where To?** icon with the magnifying glass.
- Touch the Stop Navigation button and repeat the top process to get to a new waypoint.

Garmin GPS Oregon 400T Cheatsheet



Turn On

- Press Power key, wait for GPS to boot

Turn Off

- Press and hold Power key

Backlight Strength

- Press and quickly release Power key, adjust with touchscreen options

Create New Waypoint

1. To create a waypoint of your current position touch "*Mark Waypoint*"
2. Touch "*Save and Edit*", touch "*Change Name*", type desired label, touch "*Green Check Icon*" to save

Calibrate compass

1. Whenever batteries are removed you must calibrate the compass so the map orients correctly
2. Touch "*Setup*", touch "*Heading*", touch "*Press to Begin Compass Calibration*"
3. Touch "*Start*", hold GPS level and rotate it twice on your palm

Data Fields

1. To change the data fields on the map page touch "*Map*"
2. Touch a data field at the top of the map, then select your desired data field

Calibrating the Touchscreen

1. If the touchscreen buttons are not responding properly, recalibrate the touchscreen
2. While the GPS is turned off, press and hold the power key for ~30 seconds
3. Follow instructions on the screen until calibration is complete

Field Methods Appendix: Field Guide, Random Numbers Table, Equipment Checklist

Record for every habitat unit:

Unit Type: pool, riffle, run, cascade, glide, feature (see below)
Unit Number: group pools & glides; group riffles, runs, cascades
Distance: (m) at upstream end of unit
Estimated Width: (m) visual estimate of average wetted width
Maximum Depth: (cm) deepest spot in unit
Average Depth: (cm) average depth of unit
Dominant Substrate: (1-9) covers greatest amount of surface area in unit
Subdominant Substrate: (1-9) covers 2nd most surface area in unit
Percent Fines: (%) percent of bottom consisting of sand, silt, or clay
Large Wood: (1-4, RW) count of dead and down wood in the bankfull channel
Hemlock Large Wood: count of dead and down Hemlock wood in the bankfull channel

Record for every riffle, run, or cascade leading into a pool or glide:

Riffle Crest Depth: (cm) deepest spot in hydraulic control between riffle type habitat and pool type habitat

Record for paired sample pools:

Measured Width: (m) measurement of average wetted width

Measured Width: (m) measurement of average wetted width
Hemlock Abun.: 1 None, 2 Few =1-10, 3 Some=1-50, 4 Many=>50
Hemlock Condition: 1 Healthy, 2 Infested, 3 Dead
Water Temperature: C, place thermometer in shaded area
Photo # : picture of habitat unit or crossing feature

Record for paired sample riffles:

Unit Types

Riffle (R) fast water, turbulent, gradient <12%; includes rapids, chutes, and sheets if gradient <12%
Cascade (C) fast water, turbulent, gradient ≥12%, includes sheets and chutes if gradient ≥12%
Run (RN) fast water, little to no turbulence, gradient <12%, flat bottom profile, deeper than riffles
Pool (P) slow water, may or may not be turbulent, gradient <1%, includes dammed, scour, and plunge pools
Glide (G) slow water, no surface turbulence, gradient <1%, shallow with little flow and flat bottom profile
Underground (UNGR) distance at upstream end, why dry

Features

Waterfall (FALL) distance, height, GPS
Tributary (TRIB) distance, width, in on L or R
Side Channel (SCH) distance, width, in or out on L or R
Braid (BRD) distance at downstream and upstream ends
Seep or Spring (SEEP) distance, on left or right, amount of flow
Landslide (SLID) distance, L or R, est. size and cause
Other (OTR) record distance, describe feature in comments

Crossing Features: Photograph and record the following:

Bridge (BRG) distance, height, width, road or trail name & type
Dam (DAM) distance, type, est. height, road or trail name &type
Ford (FORD) distance, road or trail name & type
Culvert (V) distance, type (pipe, box, open box, arch, open arch), size, material, natural substrate, perch (top of water to culvert) road or trail name

Substrates

1. **Organic Matter**, dead leaves detritus, etc., not living plants
2. **Clay**, sticky, holds form when balled
3. **Silt**, slick, does not hold form when balled
4. **Sand**, >silt-2mm, gritty, doesn't hold form
5. **Small Gravel**,3-16mm, sand to thumbnail
6. **Large Gravel**, 17-64mm, thumbnail to fist
7. **Cobble**, 65-256mm, fist to head
8. **Boulder**, >256, > head
9. **Bedrock**, solid parent material

Large Wood

1. <5m long, 10-55cm diameter
2. <5m long, >55cm diameter
3. >5m long, 10-55cm diameter
4. >5m long, >55cm diameter

RW: rootwad – count separately from attached LW, record in comments
do not record woody debris <10cm diameter, <1m length

End inventory

Where stream is less than 1.0 m wide for > 500 m, or channel runs dry for > 500 m, or where boundary is reached. Comment on why inventory was ended. Record time of day, detailed description of location, and GPS coordinates at endpoint, and be sure all header info is filled in on datasheets.

Random numbers for measuring every 5th unit

4	3	5	1	5	1	2	5	2	3
2	5	2	5	2	2	1	5	4	1
3	2	5	1	2	1	3	1	5	3
5	4	1	5	1	3	5	4	2	5
4	2	2	5	2	2	5	5	2	1
4	2	5	2	2	4	5	5	5	2
3	5	4	1	5	1	4	1	3	3
1	4	2	2	1	4	3	1	5	3
5	4	3	3	2	4	1	2	5	1
4	4	1	1	3	5	1	5	5	4

Random numbers for measuring every 10th unit

3	7	10	5	1	2	2	7	10	6
4	2	3	8	9	2	4	4	6	9
3	3	8	4	3	9	9	7	5	5
1	3	5	5	2	6	5	2	2	6
3	7	8	6	3	8	8	5	2	10
10	9	6	9	4	3	10	7	2	10
6	10	5	4	8	10	4	1	4	10
4	3	4	3	2	3	4	4	3	7
5	1	7	9	7	3	10	7	10	3
9	6	8	6	2	2	1	9	10	5

Choose a new random number at the beginning of each stream inventory
Use the number for the entire stream
Use the first table for streams < 1.0 km long, the second table for streams >1.0 km long

Equipment Checklist

- hipchain
- extra string for hipchain
- wading rod
- 50 m tape measure
- clinometer
- thermometer
- iPad
- handheld GPS unit
- camera
- backpack
- pencils
- flagging
- markers
- waterproof backup datasheets
- clipboard
- BVET field guide on waterproof paper
- topographic maps
- water
- water filter
- lunch
- first aid kit
- radio/cell phone
- toilet paper
- non-slip wading boots
- raingear

Remember the following for the start of each new stream or reach:

- Determine measuring interval
- Select a random number
- Fill in header information completely

Appendix B: BVET summary tables for 1995, 2005, and 2015 inventories

Appendix B contains a summary table for each stream inventoried in 1995, 2005, and 2015. The tables contain BVET summary characteristics, the percent of pools and riffles having the specified dominant and subdominant substrates (%Dom,%Sub), and large wood per kilometer. In 1995 the following data was not collected: residual depth, dominant and subdominant substrate, percent fines, and habitat unit types glide, run, and cascade (only pool and riffle). Maple Creek 1995 section is different from the 2005 and 2015 section and is excluded. For Maple Creek pools and riffles 2005, and Rocky Branch pools 2015, uncorrected visually estimated wetted stream widths are used to calculate habitat area due to lack of measured paired samples.

Stream		Belle Cove Branch	
District		Pedlar	
USGS Quadrangle		Glasgow	
Survey Dates	8/9/1995	6/1/2005	6/8/2015
Comparison Distance (km)	4.2	4.0	4.0

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	27	15	17	73	85	83
Total Area (m2)	2613 ± 218	1550 ± 220	1767 ± 394	6992 ± 441	8774 ± 1258	8468 ± 702
Correction Factor Applied	1.09	0.79	1.03	0.99	0.74	1.3
Number of Paired Samples	5	8	8	4	7	8
Total Count	92	74	80	79	72	75
Number per km	22	18	20	19	18	19
Mean Area (m2)	28	21	22	89	122	113
Mean Max. Depth (cm)	46	41	41	22	29	26
Mean Average Depth (cm)	30	28	22	12	14	11
Mean Residual Depth (cm)	--	18	13	--	--	--
% Inventoried as Glides	--	24	48	--	--	--
% Inventoried as Runs	--	--	--	--	6	5
% Inventoried as Cascades	--	--	--	--	10	3
% with >35% Fines	--	0	0	--	0	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	0,5	0,1	--	0,0	0,0
Clay	--	0,0	0,0	--	0,0	0,0
Silt	--	0,0	0,0	--	0,0	0,0
Sand	--	1,4	0,0	--	0,0	0,0
Small gravel	--	7,26	30,29	--	11,14	16,17
Large gravel	--	46,23	26,15	--	57,21	28,20
Cobble	--	12,36	11,28	--	11,58	17,28
Boulder	--	1,0	1,16	--	1,0	13,29
Bedrock	--	32,5	31,11	--	19,7	25,5

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	80	12	41
1-5 m long, >55 cm diam.	19	0	0
>5 m long, 10-55 cm diam.	201	27	28
>5 m long, >55 cm diam.	24	1	0
Total:	324	39	69

Stream	Big Marys Creek		
District	Pedlar		
USGS Quadrangle	Vesuvius/Montebello		
Survey Dates	7/19/1995	7/5/2005	6/8/2015
Comparison Distance (km)	5.4	5.4	5.4

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	26	18	29	74	82	71
Total Area (m2)	5437 ± 1098	3968 ± 417	4531 ± 946	15694 ± 2442	17992 ± 2554	10911 ± 947
Correction Factor Applied	0.95	1.03	0.99	1.02	1.18	0.92
Number of Paired Samples	10	8	12	9	8	12
Total Count	188	89	132	166	88	128
Number per km	35	16	24	30	16	24
Mean Area (m2)	29	45	34	95	204	85
Mean Max. Depth (cm)	56	50	43	26	30	23
Mean Average Depth (cm)	38	32	29	14	15	14
Mean Residual Depth (cm)	--	23	22	--	--	--
% Inventoried as Glides	--	15	39	--	--	--
% Inventoried as Runs	--	--	--	--	3	2
% Inventoried as Cascades	--	--	--	--	14	1
% with >35% Fines	--	7	6	--	1	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	0,1	1,0	--	0,0	0,0
Clay	--	0,0	0,0	--	0,0	0,0
Silt	--	3,13	0,2	--	0,0	0,0
Sand	--	1,1	3,0	--	0,1	0,2
Small gravel	--	61,26	0,3	--	41,44	0,0
Large gravel	--	9,28	43,33	--	25,36	5,15
Cobble	--	2,9	20,33	--	15,13	29,46
Boulder	--	0,0	17,24	--	0,2	51,34
Bedrock	--	24,21	17,7	--	19,3	16,3

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	7	6	84
1-5 m long, >55 cm diam.	3	0	3
>5 m long, 10-55 cm diam.	3	35	81
>5 m long, >55 cm diam.	3	2	4
Total:	15	43	172

Stream		Coxs Creek	
District		Pedlar	
USGS Quadrangle		Massies Mill	
Survey Dates	7/17/1995	6/3/2005	6/16/2015
Comparison Distance (km)	1.6	1.2	1.2

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	46	21	14	54	79	86
Total Area (m2)	2543 ± 115	1031 ± 658	584 ± 215	3015 ± 528	3957 ± 825	3517 ± 536
Correction Factor Applied	1.03	1.06	0.97	1.01	0.94	1.01
Number of Paired Samples	7	4	4	5	4	4
Total Count	137	43	28	94	42	25
Number per km	85	35	24	58	34	22
Mean Area (m2)	19	24	21	32	94	141
Mean Max. Depth (cm)	58	53	64	29	43	45
Mean Average Depth (cm)	35	34	38	15	21	15
Mean Residual Depth (cm)	--	16	27	--	--	--
% Inventoried as Glides	--	7	29	--	--	--
% Inventoried as Runs	--	--	--	--	5	0
% Inventoried as Cascades	--	--	--	--	0	0
% with >35% Fines	--	0	25	--	0	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	0,2	0,0	--	0,0	0,0
Clay	--	0,2	0,0	--	0,0	0,0
Silt	--	2,9	0,7	--	0,2	0,0
Sand	--	0,2	0,0	--	0,0	0,0
Small gravel	--	51,19	57,29	--	7,21	0,32
Large gravel	--	7,19	0,18	--	5,14	4,0
Cobble	--	30,28	0,7	--	33,50	0,64
Boulder	--	9,16	43,39	--	52,12	96,4
Bedrock	--	0,2	0,0	--	2,0	0,0

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	71	4	38
1-5 m long, >55 cm diam.	4	0	1
>5 m long, 10-55 cm diam.	13	41	57
>5 m long, >55 cm diam.	2	0	4
Total:	91	45	100

Stream	Dancing Creek		
District	Pedlar		
USGS Quadrangle	Big Island/Buena Vista		
Survey Dates	8/16/1995	6/2/2005	6/14/2015
Comparison Distance (km)	2.9	2.6	2.6

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	42	31	19	58	69	81
Total Area (m2)	4341 ± 176	2433 ± 650	1678 ± 184	6023 ± 689	5417 ± 598	7307 ± 585
Correction Factor Applied	1	0.88	0.95	1.11	1.04	1.16
Number of Paired Samples	5	9	5	5	7	5
Total Count	112	87	38	98	68	32
Number per km	39	33	15	34	26	12
Mean Area (m2)	39	28	44	61	80	228
Mean Max. Depth (cm)	38	44	46	16	23	32
Mean Average Depth (cm)	24	28	23	8	12	10
Mean Residual Depth (cm)	--	17	18	--	--	--
% Inventoried as Glides	--	39	45	--	--	--
% Inventoried as Runs	--	--	--	--	0	3
% Inventoried as Cascades	--	--	--	--	1	3
% with >35% Fines	--	11	13	--	0	3

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	1,22	16,39	--	0,6	0,0
Clay	--	0,0	0,0	--	0,0	0,0
Silt	--	0,10	5,3	--	0,3	0,0
Sand	--	2,9	8,0	--	0,6	3,3
Small gravel	--	9,21	0,8	--	25,35	6,22
Large gravel	--	3,8	3,13	--	4,12	6,22
Cobble	--	14,23	11,18	--	25,35	47,25
Boulder	--	15,6	16,3	--	9,3	16,25
Bedrock	--	55,1	42,16	--	37,0	22,3

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	50	19	65
1-5 m long, >55 cm diam.	4	1	0
>5 m long, 10-55 cm diam.	29	44	45
>5 m long, >55 cm diam.	12	8	2
Total:	96	72	112

Stream		Enchanted Creek	
District		Pedlar	
USGS Quadrangle		Buena Vista	
Survey Dates	5/22/1995	6/1/2005	6/10/2015
Comparison Distance (km)	3.0	2.9	3.1

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	38	16	7	62	84	93
Total Area (m2)	4318 ± 352	2217 ± 294	886 ± 156	7036 ± 665	11383 ± 1743	11176 ± 898
Correction Factor Applied	1.09	0.97	0.75	1.02	1.17	0.95
Number of Paired Samples	11	8	5	9	6	6
Total Count	222	70	30	184	72	37
Number per km	73	24	10	61	25	12
Mean Area (m2)	19	32	30	38	158	302
Mean Max. Depth (cm)	40	59	64	25	28	44
Mean Average Depth (cm)	26	36	38	13	13	21
Mean Residual Depth (cm)	--	21	24	--	--	--
% Inventoried as Glides	--	1	13	--	--	--
% Inventoried as Runs	--	--	--	--	3	8
% Inventoried as Cascades	--	--	--	--	13	5
% with >35% Fines	--	10	53	--	0	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	1,1	0,7	--	0,0	0,0
Clay	--	0,0	0,0	--	0,0	0,0
Silt	--	0,0	3,0	--	0,0	0,0
Sand	--	6,3	47,23	--	0,1	0,5
Small gravel	--	10,14	7,13	--	1,3	8,16
Large gravel	--	9,16	0,13	--	4,8	0,14
Cobble	--	9,31	10,23	--	28,47	22,41
Boulder	--	33,27	30,17	--	53,29	62,16
Bedrock	--	33,7	3,3	--	14,11	8,8

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	67	34	98
1-5 m long, >55 cm diam.	14	0	1
>5 m long, 10-55 cm diam.	39	48	70
>5 m long, >55 cm diam.	8	21	2
Total:	128	104	172

Stream	Greasy Spring Branch		
District	Pedlar		
USGS Quadrangle	Montebello		
Survey Dates	7/26/1995	5/31/2005	6/15/2015
Comparison Distance (km)	1.8	1.9	1.6

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	18	13	12	82	87	88
Total Area (m2)	833 ± 586	1008 ± 66	470 ± 96	3707 ± 320	6757 ± 1641	3311 ± 545
Correction Factor Applied	0.84	1	0.91	0.91	1.19	0.95
Number of Paired Samples	5	7	4	4	7	4
Total Count	80	70	28	74	79	29
Number per km	43	36	18	40	41	19
Mean Area (m2)	10	14	17	50	86	114
Mean Max. Depth (cm)	54	46	53	34	34	37
Mean Average Depth (cm)	38	31	32	18	19	20
Mean Residual Depth (cm)	--	15	21	--	--	--
% Inventoried as Glides	--	9	21	--	--	--
% Inventoried as Runs	--	--	--	--	1	0
% Inventoried as Cascades	--	--	--	--	22	10
% with >35% Fines	--	60	4	--	1	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	11,19	0,0	--	6,6	0,0
Clay	--	0,1	0,0	--	0,0	0,0
Silt	--	11,51	0,0	--	0,0	0,0
Sand	--	41,9	4,0	--	0,1	0,0
Small gravel	--	31,13	25,18	--	9,9	0,3
Large gravel	--	1,6	43,25	--	25,10	3,10
Cobble	--	1,0	0,21	--	23,35	14,38
Boulder	--	0,1	21,18	--	14,34	69,31
Bedrock	--	1,0	7,18	--	23,4	14,17

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	41	25	147
1-5 m long, >55 cm diam.	14	20	1
>5 m long, 10-55 cm diam.	94	108	97
>5 m long, >55 cm diam.	34	25	6
Total:	183	178	251

Stream		Kennedy Creek	
District		Pedlar	
USGS Quadrangle		Big levels	
Survey Dates	5/30/1995	6/2/2005	6/11/2015
Comparison Distance (km)	4.4	4.5	4.5

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	27	23	11	73	77	89
Total Area (m2)	3828 ± 277	3410 ± 324	1719 ± 169	10354 ± 1171	11551 ± 673	13479 ± 1449
Correction Factor Applied	1.10	1.00	0.98	0.93	1.14	1.12
Number of Paired Samples	12	11	8	10	11	6
Total Count	213	115	66	189	115	67
Number per km	49	26	15	43	26	15
Mean Area (m2)	18	30	26	55	100	201
Mean Max. Depth (cm)	55	62	51	33	29	35
Mean Average Depth (cm)	35	38	29	16	15	16
Mean Residual Depth (cm)	--	25	18	--	--	--
% Inventoried as Glides	--	0	44	--	--	--
% Inventoried as Runs	--	--	--	--	3	7
% Inventoried as Cascades	--	--	--	--	6	0
% with >35% Fines	--	0	3	--	0	1

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	0,3	17,26	--	0,2	3,0
Clay	--	0,1	0,0	--	0,0	0,0
Silt	--	1,0	0,0	--	0,0	0,0
Sand	--	0,0	2,2	--	0,0	0,1
Small gravel	--	7,10	20,8	--	0,3	10,13
Large gravel	--	17,11	12,30	--	2,9	13,27
Cobble	--	38,27	21,21	--	41,45	33,27
Boulder	--	27,43	23,12	--	47,40	34,31
Bedrock	--	10,4	6,2	--	10,2	6,0

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	15	5	29
1-5 m long, >55 cm diam.	2	0	0
>5 m long, 10-55 cm diam.	15	12	29
>5 m long, >55 cm diam.	5	1	1
Total:	38	18	58

Stream	King Creek		
District	Pedlar		
USGS Quadrangle	Montebello/Massies Mill		
Survey Dates	7/27/1995	6/30/2005	8/18/2015
Comparison Distance (km)	1.7	1.7	1.7

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	27	21	11	73	79	89
Total Area (m2)	1129 ± 287	1179 ± 317	437 ± 90	3041 ± 563	4440 ± 1416	3423 ± 2067
Correction Factor Applied	0.95	0.99	0.94	1.06	1	0.82
Number of Paired Samples	6	5	3	5	5	3
Total Count	118	54	24	96	47	24
Number per km	68	33	14	55	28	14
Mean Area (m2)	10	22	18	32	94	143
Mean Max. Depth (cm)	44	48	59	26	25	42
Mean Average Depth (cm)	31	32	35	15	15	15
Mean Residual Depth (cm)	--	18	27	--	--	--
% Inventoried as Glides	--	0	21	--	--	--
% Inventoried as Runs	--	--	--	--	0	0
% Inventoried as Cascades	--	--	--	--	0	0
% with >35% Fines	--	37	21	--	0	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	2,4	0,0	--	0,0	0,0
Clay	--	0,0	0,0	--	0,0	0,0
Silt	--	0,6	4,17	--	0,0	0,0
Sand	--	31,19	0,21	--	0,0	0,0
Small gravel	--	20,31	38,29	--	6,43	13,50
Large gravel	--	0,0	0,8	--	0,0	0,33
Cobble	--	6,6	13,4	--	23,21	67,8
Boulder	--	7,15	17,13	--	26,28	13,0
Bedrock	--	33,20	29,8	--	45,9	8,8

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	26	14	31
1-5 m long, >55 cm diam.	2	0	0
>5 m long, 10-55 cm diam.	41	41	31
>5 m long, >55 cm diam.	2	1	3
Total:	72	56	65

Stream		Little Cove Creek	
District		Pedlar	
USGS Quadrangle		Forks of Buffalo	
Survey Dates	7/21/1989	6/2/2005	6/15/2015
Comparison Distance (km)	1.1	1.2	1.1

Summary Characteristics	Pools			Riffles		
	1989	2005	2015	1989	2005	2015
% of Total Stream Area	28	24	9	72	76	91
Total Area (m2)	1455 ± 279	1034 ± 161	501 ± 152	3702 ± 386	3205 ± 389	5290 ± 354
Correction Factor Applied	1.07	0.95	0.89	0.98	0.98	1.09
Number of Paired Samples	15	5	3	8	5	3
Total Count	79	50	21	78	50	19
Number per km	70	42	19	69	42	17
Mean Area (m2)	18	21	24	47	64	278
Mean Max. Depth (cm)	59	60	57	28	25	40
Mean Average Depth (cm)	38	34	27	18	12	13
Mean Residual Depth (cm)	--	20	19	--	--	--
% Inventoried as Glides	38	0	14	--	--	--
% Inventoried as Runs	--	--	--	--	0	0
% Inventoried as Cascades	--	--	--	58	52	42
% with >35% Fines	--	0	57	--	0	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1989	2005	2015	1989	2005	2015
Organic matter	0,0	0,2	5,0	0,0	0,10	0,11
Clay	0,0	0,0	0,0	0,0	0,0	0,0
Silt	0,0	0,0	29,38	0,0	0,0	0,0
Sand	1,0	0,0	5,5	0,0	0,0	0,0
Small gravel	0,0	56,22	52,14	0,0	0,16	0,53
Large gravel	11,1	4,6	5,10	5,0	2,6	0,0
Cobble	25,23	2,2	0,5	26,14	0,28	0,5
Boulder	38,34	20,38	0,19	38,33	58,32	63,26
Bedrock	27,6	18,30	5,10	32,6	38,8	37,5

Large Wood per Km	1989	2005	2015
1-5 m long, 10-55 cm diam.	71	10	77
1-5 m long, >55 cm diam.	4	2	0
>5 m long, 10-55 cm diam.	24	43	43
>5 m long, >55 cm diam.	4	16	3
Total:	102	71	123

Stream	Love Lady Creek		
District	Pedlar		
USGS Quadrangle	Big Island/Buena Vista		
Survey Dates	8/14/1995	5/31/2005	6/12/2015
Comparison Distance (km)	2.0	2.1	2.2

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	50	28	41	50	72	59
Total Area (m2)	2505 ± 18838	1824 ± 100	2545 ± 163	2538 ± 2455	4670 ± 1328	3602 ± 1130
Correction Factor Applied	1.02	1.06	0.96	0.92	1.22	0.98
Number of Paired Samples	2	5	9	2	5	7
Total Count	68	52	52	58	50	52
Number per km	34	25	24	29	24	24
Mean Area (m2)	37	35	49	44	93	69
Mean Max. Depth (cm)	41	40	38	19	22	18
Mean Average Depth (cm)	27	22	23	10	10	8
Mean Residual Depth (cm)	--	13	16	--	--	--
% Inventoried as Glides	--	0	62	--	--	--
% Inventoried as Runs	--	--	--	--	0	0
% Inventoried as Cascades	--	--	--	--	0	0
% with >35% Fines	--	10	12	--	2	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	2,15	2,2	--	0,0	0,0
Clay	--	0,0	0,0	--	0,0	0,0
Silt	--	0,0	0,0	--	0,0	0,0
Sand	--	4,4	6,6	--	0,2	0,0
Small gravel	--	33,27	8,37	--	14,14	0,52
Large gravel	--	6,19	6,29	--	16,40	27,38
Cobble	--	10,19	40,12	--	42,34	62,10
Boulder	--	4,8	12,10	--	12,4	0,0
Bedrock	--	42,8	27,6	--	16,6	12,0

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	24	12	53
1-5 m long, >55 cm diam.	2	0	0
>5 m long, 10-55 cm diam.	20	14	23
>5 m long, >55 cm diam.	4	3	0
Total:	49	30	76

Stream		Loves Run	
District		Pedlar	
USGS Quadrangle		Big levels	
Survey Dates	6/5/1995	6/3/2005	6/14/2015
Comparison Distance (km)	2.5	2.3	2.3

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	24	19	5	76	81	95
Total Area (m2)	1466 ± 361	1056 ± 201	255 ± 43	4770 ± 545	4368 ± 2258	4732 ± 450
Correction Factor Applied	0.95	1.07	0.86	1.07	0.97	0.86
Number of Paired Samples	7	5	5	6	4	5
Total Count	133	48	13	110	43	14
Number per km	53	21	6	44	19	6
Mean Area (m2)	11	22	20	43	102	338
Mean Max. Depth (cm)	36	45	49	21	27	30
Mean Average Depth (cm)	26	27	28	12	14	11
Mean Residual Depth (cm)	--	14	21	--	--	--
% Inventoried as Glides	--	31	31	--	--	--
% Inventoried as Runs	--	--	--	--	0	0
% Inventoried as Cascades	--	--	--	--	0	7
% with >35% Fines	--	2	0	--	0	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	0,6	46,23	--	0,0	0,0
Clay	--	0,0	0,0	--	0,0	0,0
Silt	--	0,0	0,0	--	0,0	0,0
Sand	--	0,2	0,0	--	0,0	0,0
Small gravel	--	6,17	0,8	--	2,5	0,21
Large gravel	--	23,21	0,15	--	23,26	7,50
Cobble	--	50,21	31,31	--	60,33	79,14
Boulder	--	2,33	8,8	--	7,37	0,7
Bedrock	--	19,0	15,15	--	7,0	14,7

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	21	13	75
1-5 m long, >55 cm diam.	1	0	1
>5 m long, 10-55 cm diam.	9	44	83
>5 m long, >55 cm diam.	0	5	2
Total:	32	62	161

Stream		Maple Creek	
District		Pedlar	
USGS Quadrangle		Big Island	
Survey Dates	--	6/3/2005	6/14/2015
Comparison Distance (km)	--	0.6	0.9

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	--	39	30	0	61	70
Total Area (m2)	--	427	478 ± 78	0	560	1117 ± 166
Correction Factor Applied	--	1	1.06	0	1.2	0.99
Number of Paired Samples	--	1	4	0	1	4
Total Count	--	4	21	0	7	22
Number per km	--	7	25	0	12	26
Mean Area (m2)	--	107	23	0	96	51
Mean Max. Depth (cm)	--	39	26	0	28	15
Mean Average Depth (cm)	--	25	15	0	9	7
Mean Residual Depth (cm)	--	28	8	--	--	--
% Inventoried as Glides	--	50	90	--	--	--
% Inventoried as Runs	--	--	--	--	71	0
% Inventoried as Cascades	--	--	--	--	0	0
% with >35% Fines	--	75	71	--	100	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	0,0	0,0	--	0,0	0,0
Clay	--	0,0	0,0	--	0,0	0,0
Silt	--	0,100	0,0	--	0,57	0,0
Sand	--	100,0	52,29	--	100,0	0,0
Small gravel	--	0,0	0,43	--	0,29	5,64
Large gravel	--	0,0	0,10	--	0,14	0,27
Cobble	--	0,0	33,10	--	0,0	91,9
Boulder	--	0,0	0,0	--	0,0	0,0
Bedrock	--	0,0	14,10	--	0,0	5,0

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	--	8	35
1-5 m long, >55 cm diam.	--	0	0
>5 m long, 10-55 cm diam.	--	18	24
>5 m long, >55 cm diam.	--	0	0
Total:	--	27	59

Stream	North Fork Bennetts Run		
District	Pedlar		
USGS Quadrangle	Glasgow/Buena Vista		
Survey Dates	8/9/1995	6/2/2005	8/20/2015
Comparison Distance (km)	1.8	1.8	1.8

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	39	17	21	61	83	79
Total Area (m2)	1755 ± 195	927 ± 359	941 ± 153	2776 ± 163	4667 ± 1039	3458 ± 120
Correction Factor Applied	1.02	0.81	1.1	1.01	1.11	0.94
Number of Paired Samples	6	4	3	5	4	3
Total Count	117	41	29	103	47	29
Number per km	64	23	16	56	26	16
Mean Area (m2)	15	23	32	27	99	119
Mean Max. Depth (cm)	46	55	53	21	32	29
Mean Average Depth (cm)	30	39	31	11	13	10
Mean Residual Depth (cm)	--	28	24	--	--	--
% Inventoried as Glides	--	2	28	--	--	--
% Inventoried as Runs	--	--	--	--	0	0
% Inventoried as Cascades	--	--	--	--	43	21
% with >35% Fines	--	37	66	--	6	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	0,2	0,0	--	0,9	0,10
Clay	--	0,0	0,0	--	0,0	0,0
Silt	--	15,24	24,3	--	0,4	0,7
Sand	--	10,12	17,41	--	2,6	0,0
Small gravel	--	7,34	21,31	--	6,28	0,7
Large gravel	--	12,15	3,3	--	13,32	7,3
Cobble	--	2,10	7,3	--	38,17	17,31
Boulder	--	0,0	3,3	--	4,0	48,31
Bedrock	--	54,2	24,14	--	36,4	28,10

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	122	9	59
1-5 m long, >55 cm diam.	13	13	1
>5 m long, 10-55 cm diam.	144	46	38
>5 m long, >55 cm diam.	42	6	4
Total:	320	73	102

Stream		Pedlar Gap Run	
District		Pedlar	
USGS Quadrangle		Buena Vista	
Survey Dates	8/14/1995	5/31/2005	6/8/2015
Comparison Distance (km)	2.1	1.9	2.0

Summary Characteristics	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
% of Total Stream Area	32	10	13	68	90	87
Total Area (m2)	1614 ± 74	602 ± 257	741 ± 88	3440 ± 212	5273 ± 1218	5137 ± 575
Correction Factor Applied	1.05	0.79	0.88	1.09	1.12	0.79
Number of Paired Samples	7	4	7	6	7	7
Total Count	134	39	34	116	54	46
Number per km	63	21	17	54	29	23
Mean Area (m2)	12	15	22	30	98	109
Mean Max. Depth (cm)	38	42	41	20	24	27
Mean Average Depth (cm)	26	31	25	12	13	14
Mean Residual Depth (cm)	--	17	16	--	--	--
% Inventoried as Glides	--	15	18	--	--	--
% Inventoried as Runs	--	--	--	--	20	13
% Inventoried as Cascades	--	--	--	--	7	7
% with >35% Fines	--	74	65	--	7	4

Substrate (%Dom,%Sub)	Pools			Riffles		
	1995	2005	2015	1995	2005	2015
Organic matter	--	0,10	0,3	--	0,11	0,2
Clay	--	0,0	0,0	--	0,2	0,0
Silt	--	0,3	0,0	--	0,0	0,0
Sand	--	0,0	59,12	--	0,0	2,2
Small gravel	--	21,28	21,21	--	19,39	22,28
Large gravel	--	3,3	15,24	--	4,0	37,46
Cobble	--	0,5	3,15	--	0,4	11,15
Boulder	--	31,18	3,26	--	30,24	22,7
Bedrock	--	38,26	0,0	--	39,11	7,0

Large Wood per Km	1995	2005	2015
1-5 m long, 10-55 cm diam.	20	21	25
1-5 m long, >55 cm diam.	0	0	0
>5 m long, 10-55 cm diam.	18	10	35
>5 m long, >55 cm diam.	4	1	0
Total:	43	32	60

Stream		Rocky Branch	
District		Pedlar	
USGS Quadrangle		Forks of Buffalo	
Survey Dates	7/21/1989	6/2/2005	6/15/2015
Comparison Distance (km)	1.0	1.0	0.3

Summary Characteristics	Pools			Riffles		
	1989	2005	2015	1989	2005	2015
% of Total Stream Area	26	21	12	74	79	88
Total Area (m2)	776 ± 75	539 ± 63	103	2161 ± 176	2090 ± 694	787 ± 296
Correction Factor Applied	0.93	0.99	1.03	0.99	0.9	1.25
Number of Paired Samples	12	3	1	5	4	2
Total Count	67	39	7	69	47	10
Number per km	65	39	24	67	47	34
Mean Area (m2)	10	14	15	31	44	79
Mean Max. Depth (cm)	52	54	58	18	24	45
Mean Average Depth (cm)	36	31	44	13	11	17
Mean Residual Depth (cm)	--	20	36	--	--	--
% Inventoried as Glides	43	0	0	--	--	--
% Inventoried as Runs	--	--	--	--	0	10
% Inventoried as Cascades	--	--	--	49	38	50
% with >35% Fines	--	8	14	--	0	0

Substrate (%Dom,%Sub)	Pools			Riffles		
	1989	2005	2015	1989	2005	2015
Organic matter	0,0	0,0	0,14	0,0	0,21	0,10
Clay	0,0	0,3	0,0	0,0	0,0	0,0
Silt	0,0	0,3	14,0	0,0	0,0	0,0
Sand	16,21	0,0	0,14	0,0	0,0	0,0
Small gravel	72,19	41,31	43,14	3,10	4,43	0,0
Large gravel	3,31	5,3	0,14	0,12	2,0	0,40
Cobble	9,6	0,3	0,14	29,10	0,6	10,10
Boulder	0,1	13,31	0,29	43,12	49,17	60,10
Bedrock	9,0	41,26	43,0	25,0	43,13	30,30

Large Wood per Km	1989	2005	2015
1-5 m long, 10-55 cm diam.	33	0	106
1-5 m long, >55 cm diam.	11	9	0
>5 m long, 10-55 cm diam.	20	49	62
>5 m long, >55 cm diam.	14	9	10
Total:	78	67	178

Appendix C: BVET data shown longitudinally for each 2015 stream inventory

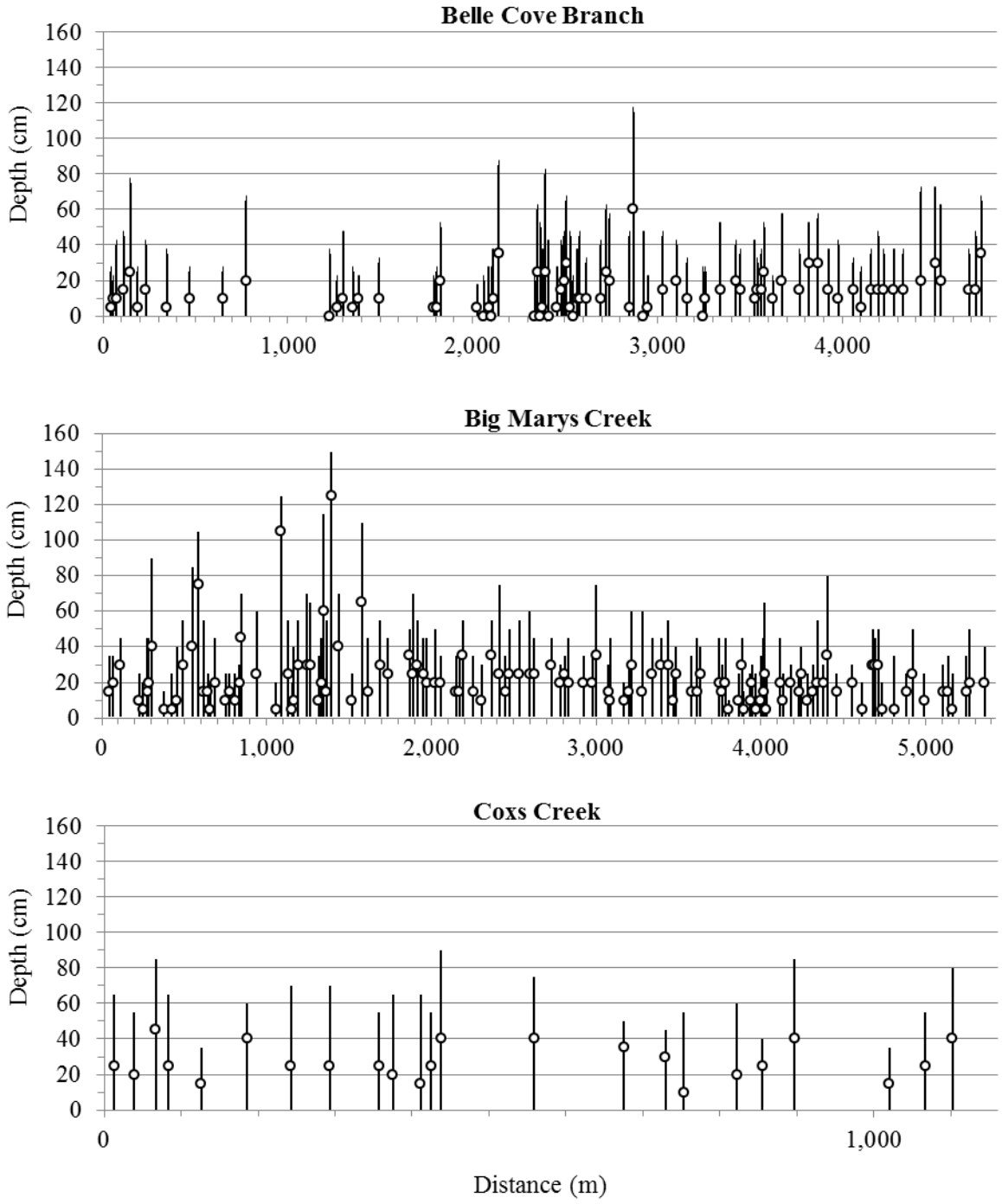


Figure C1. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

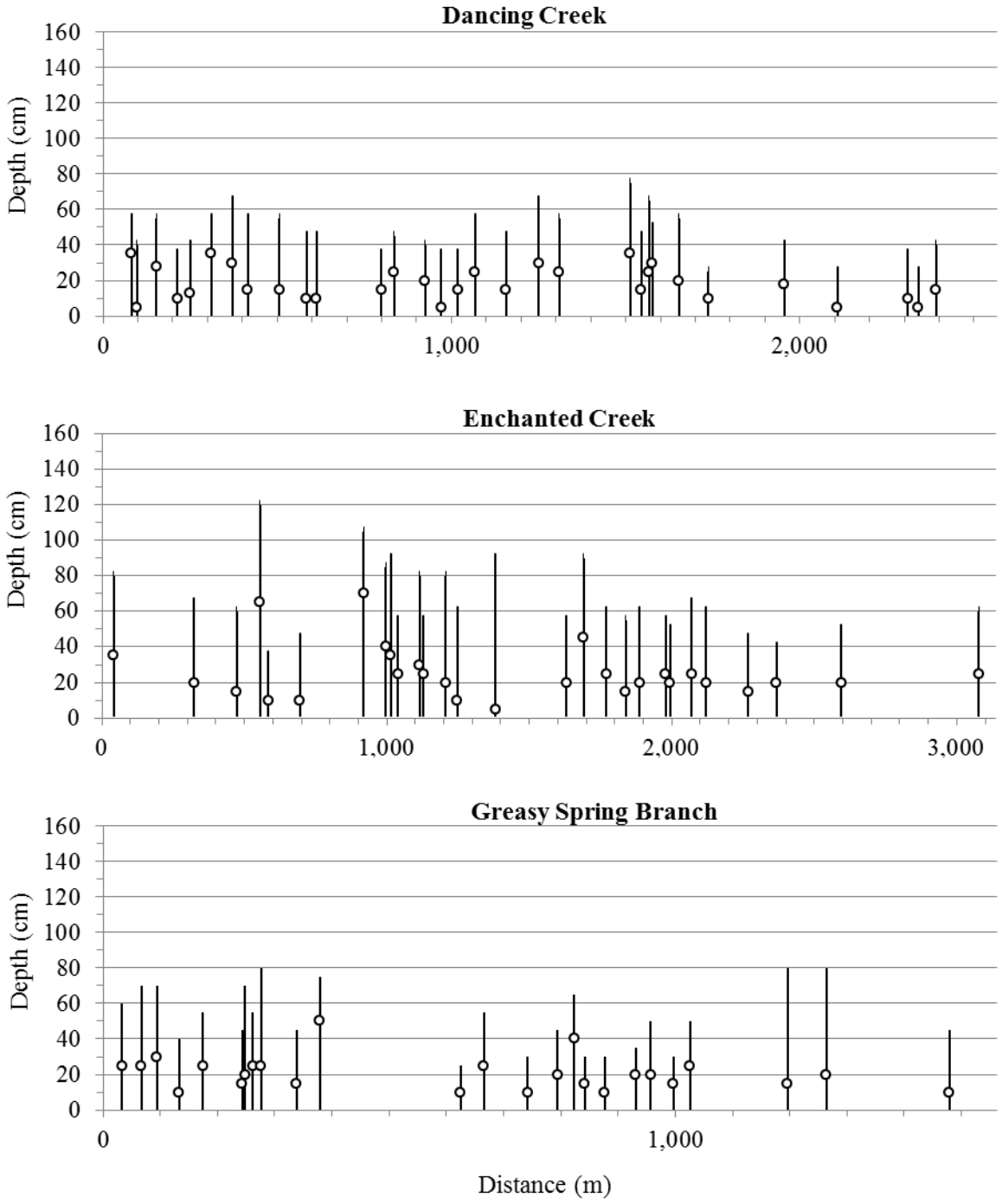


Figure C1 continued. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

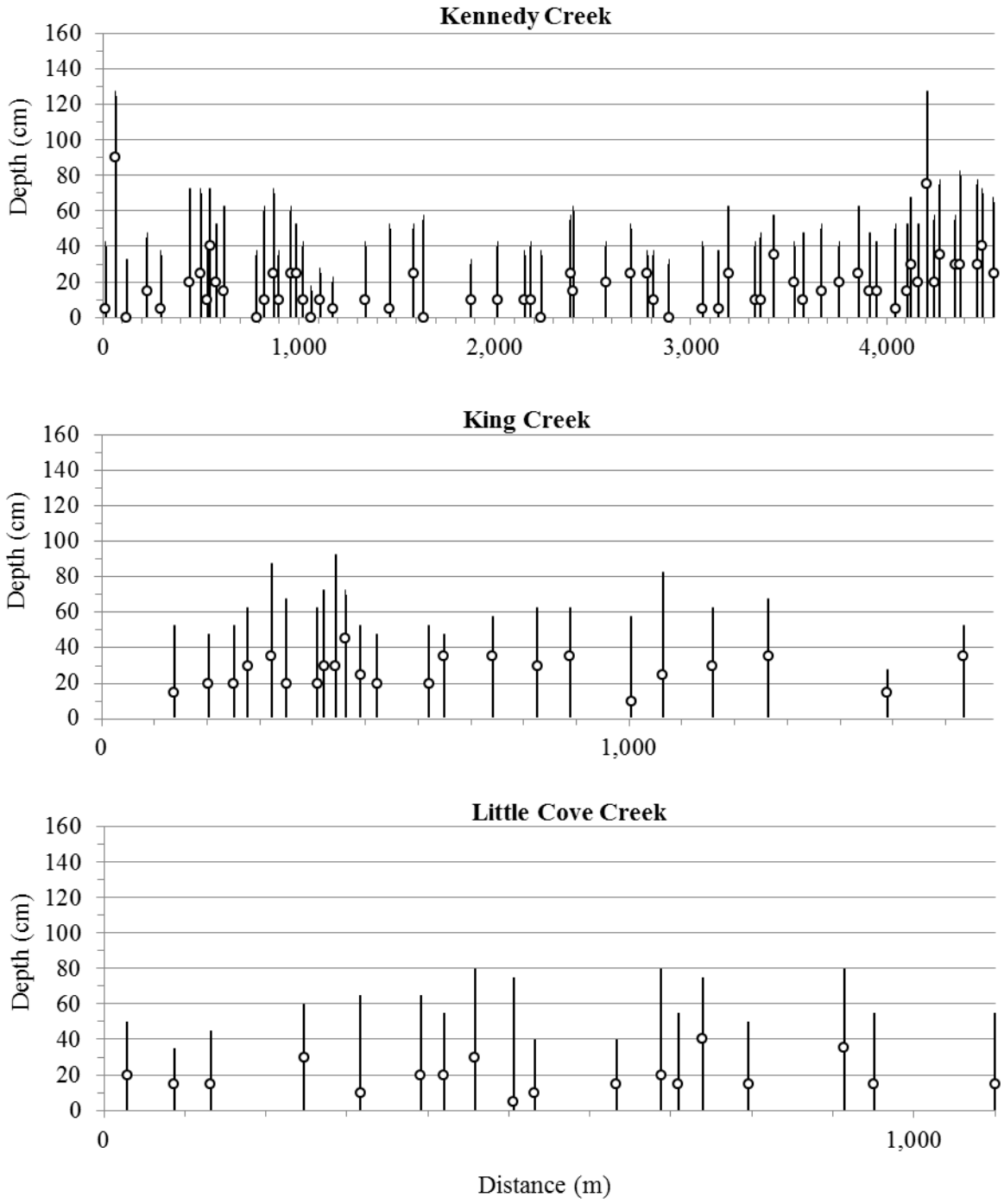


Figure C1 continued. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

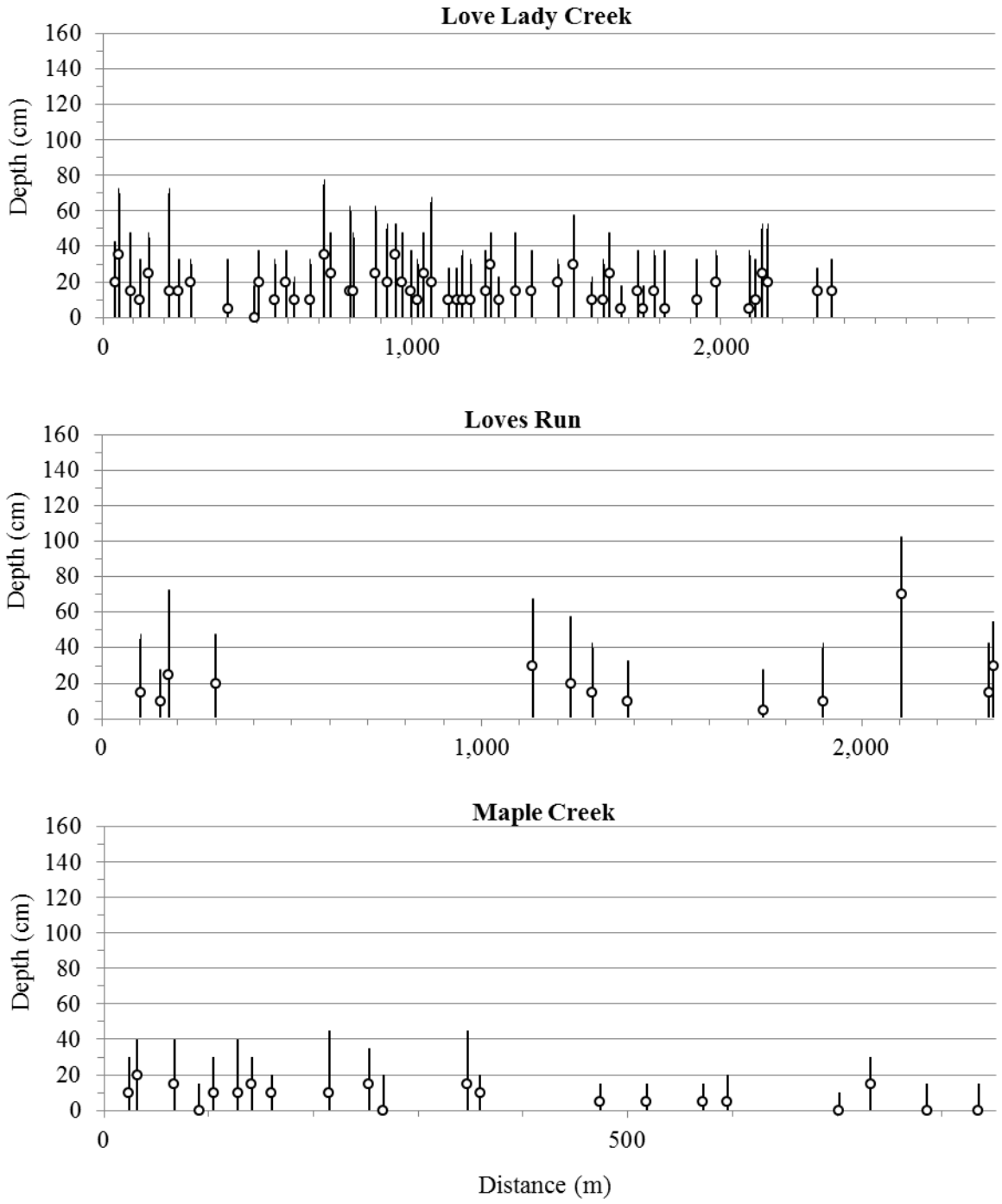


Figure C1 continued. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

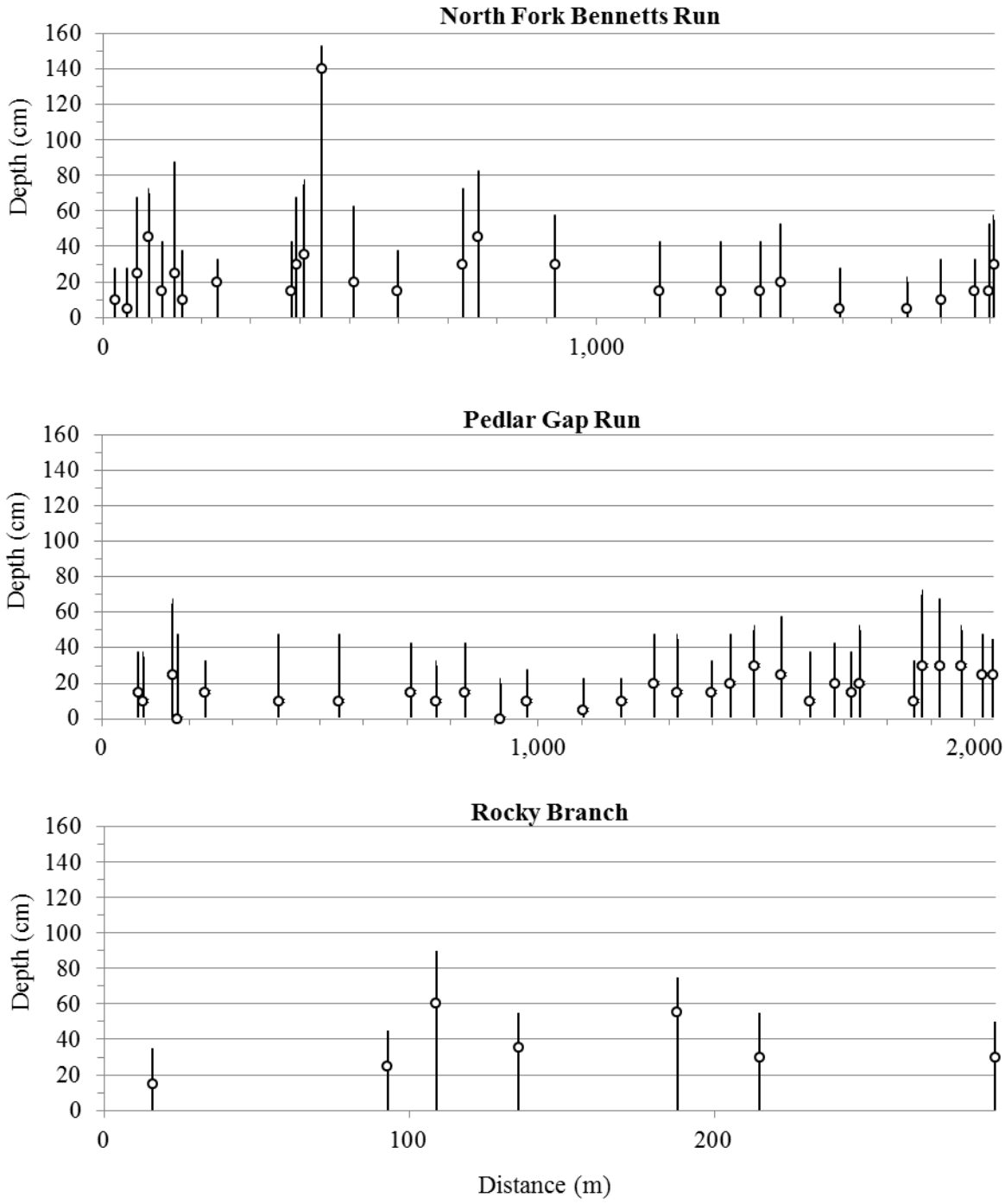


Figure C1 continued. Maximum pool depth (bars) and residual pool depth (circles) shown longitudinally for each stream inventory.

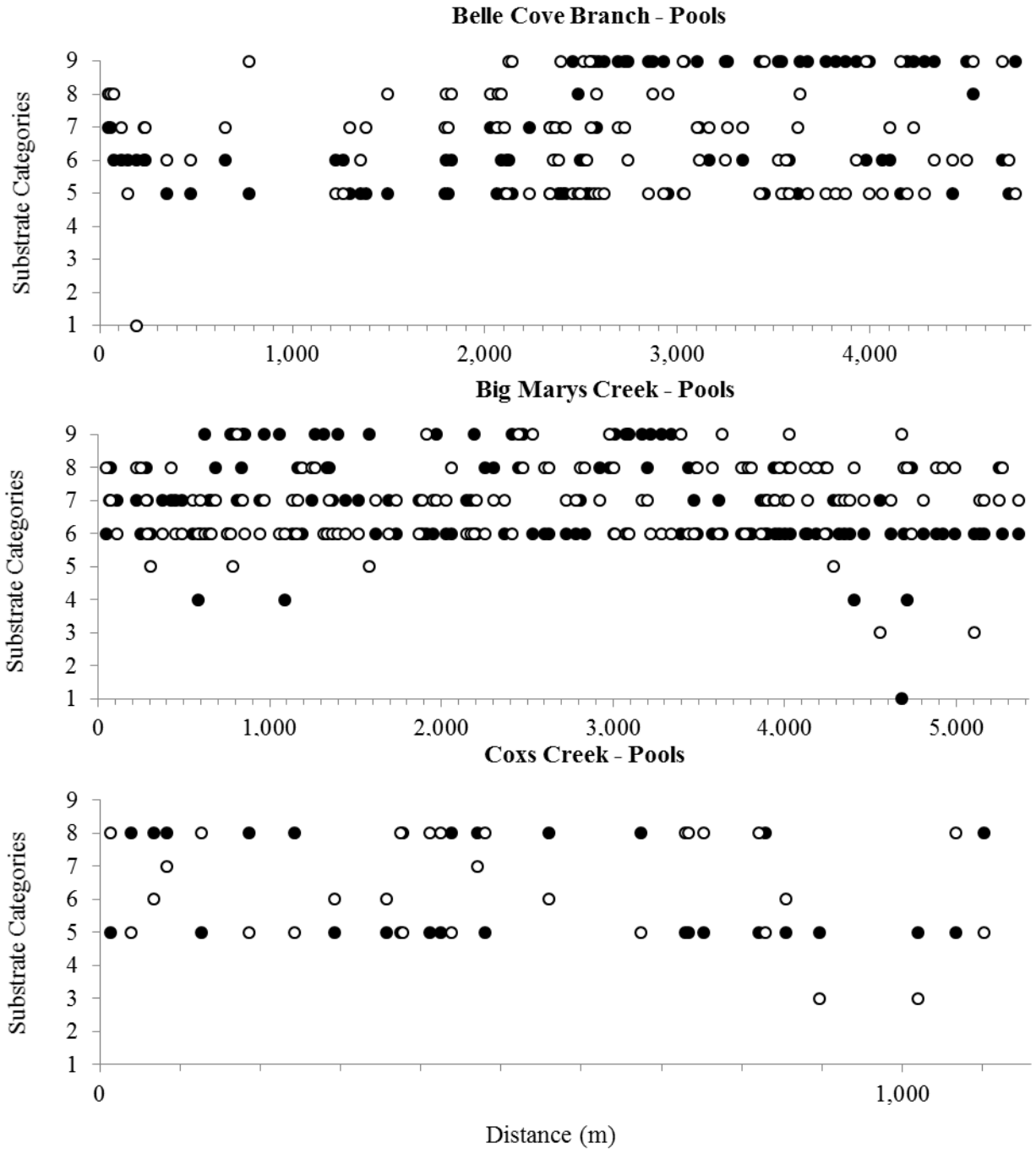


Figure C2. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

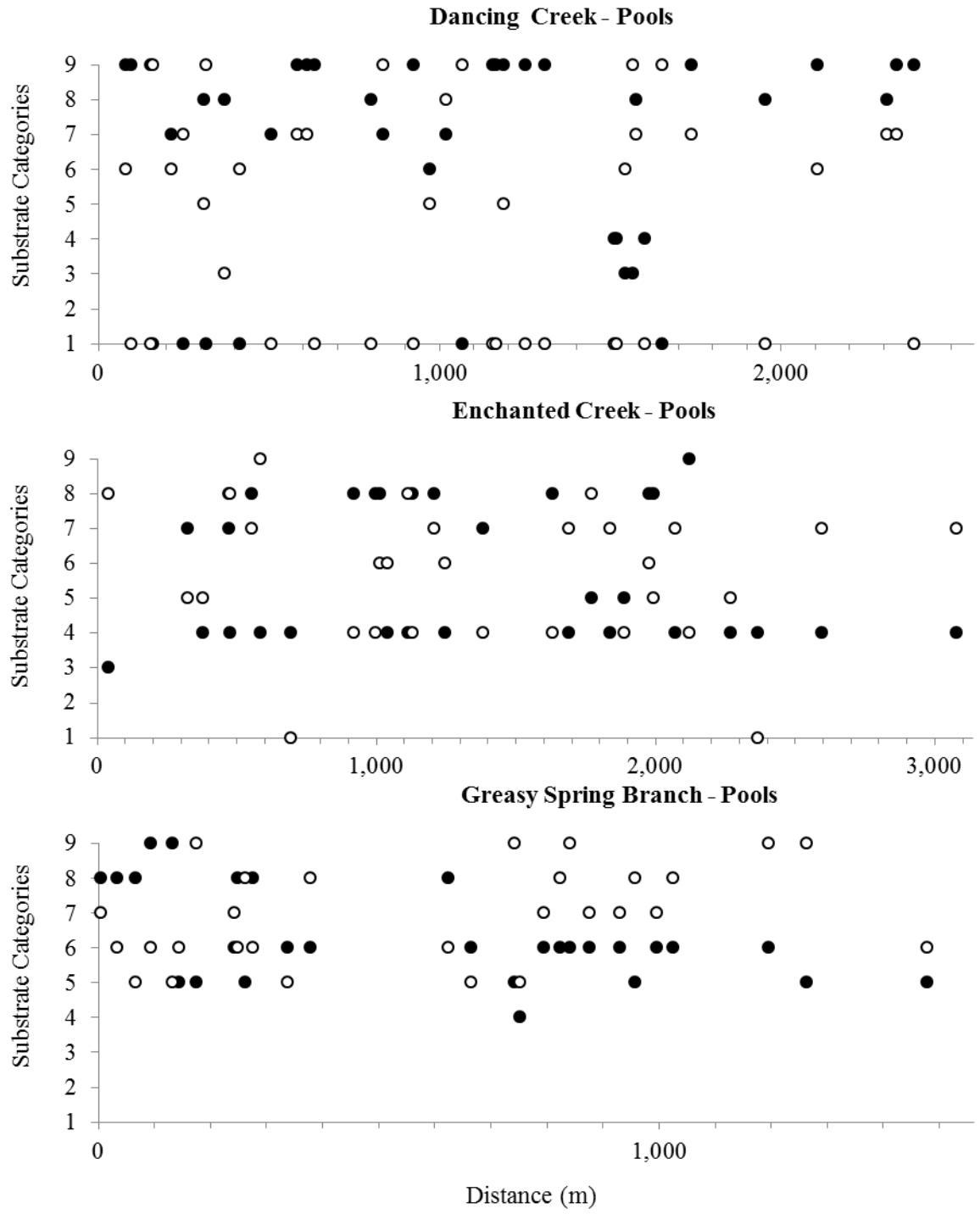


Figure C2 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

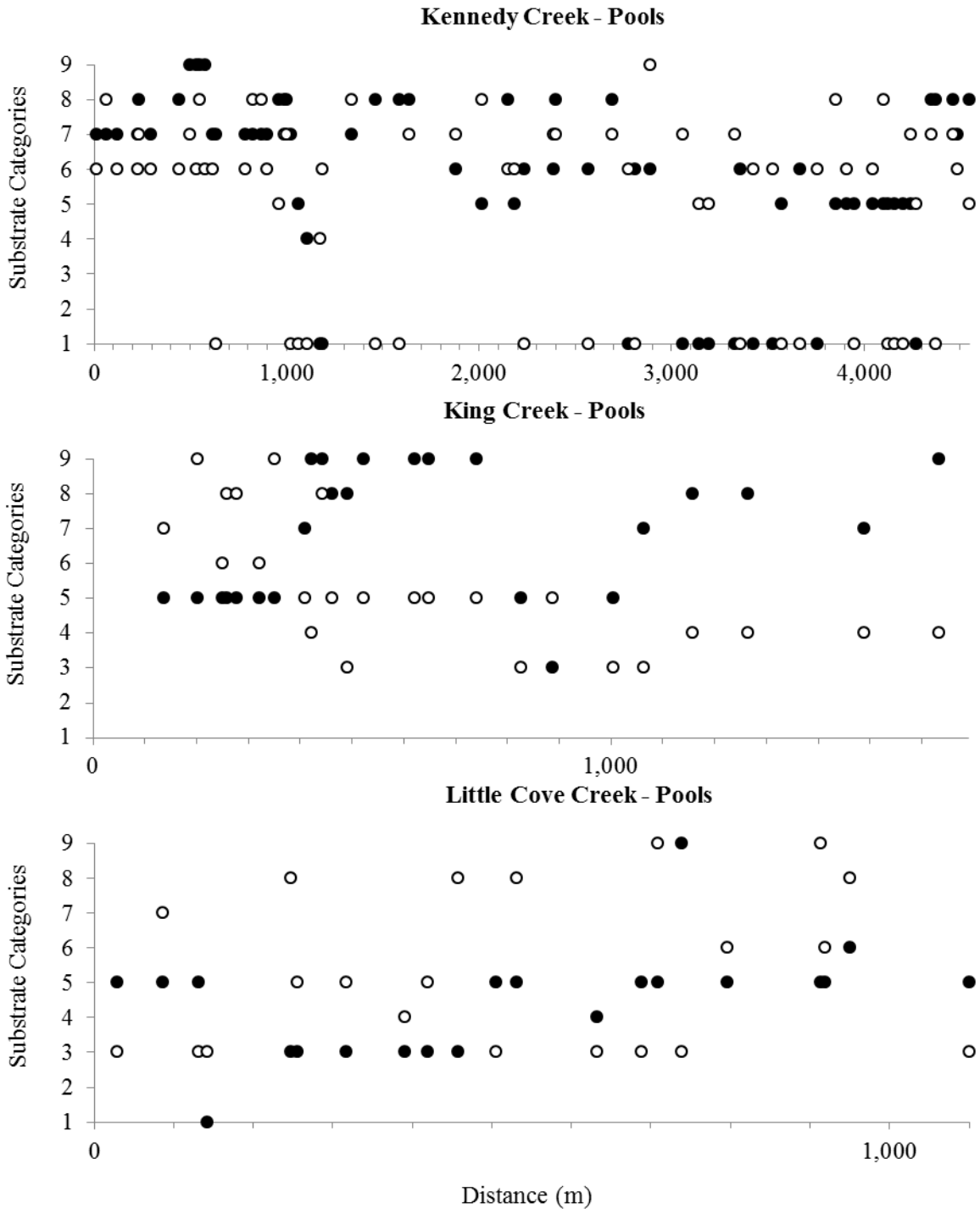


Figure C2 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

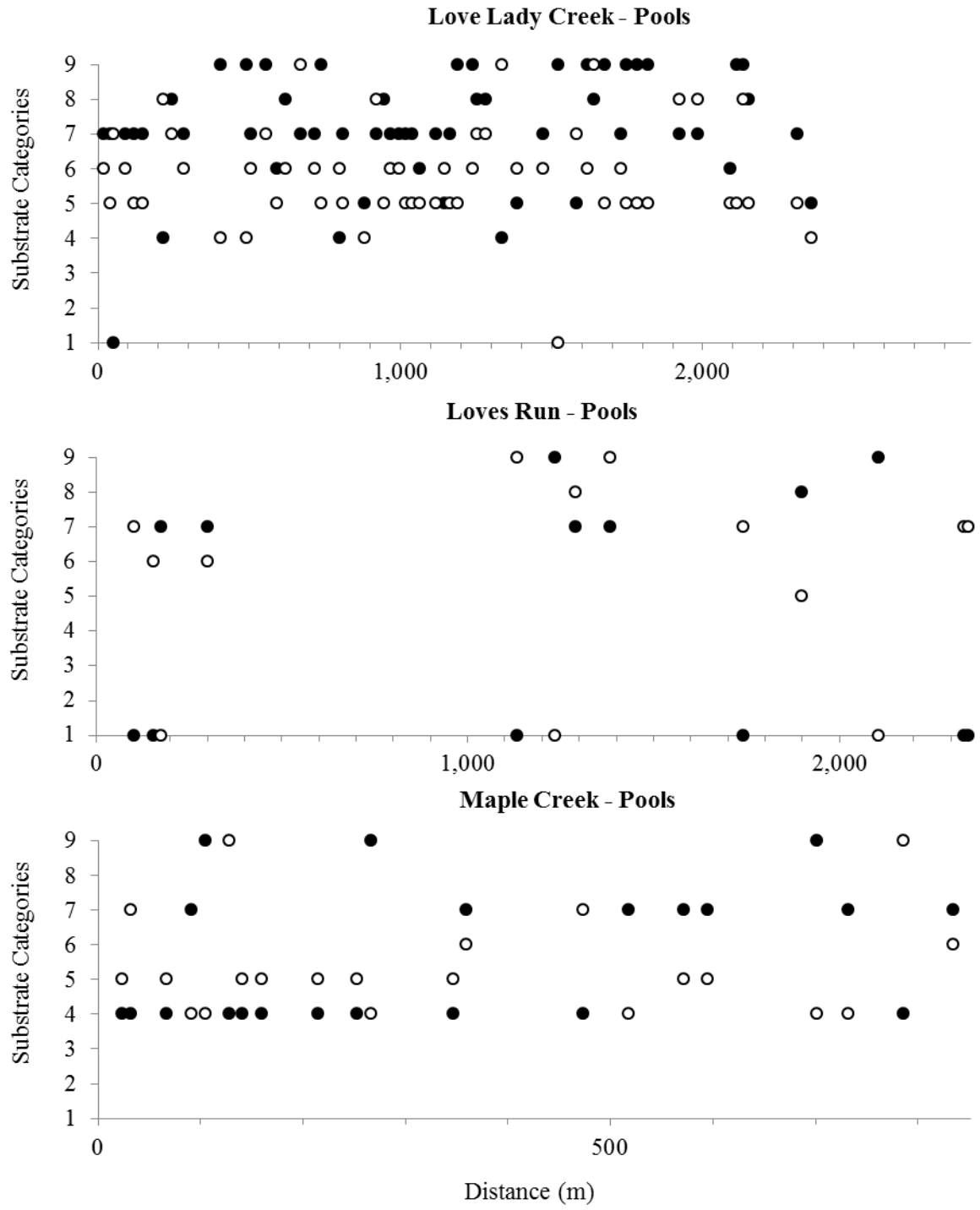


Figure C2 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

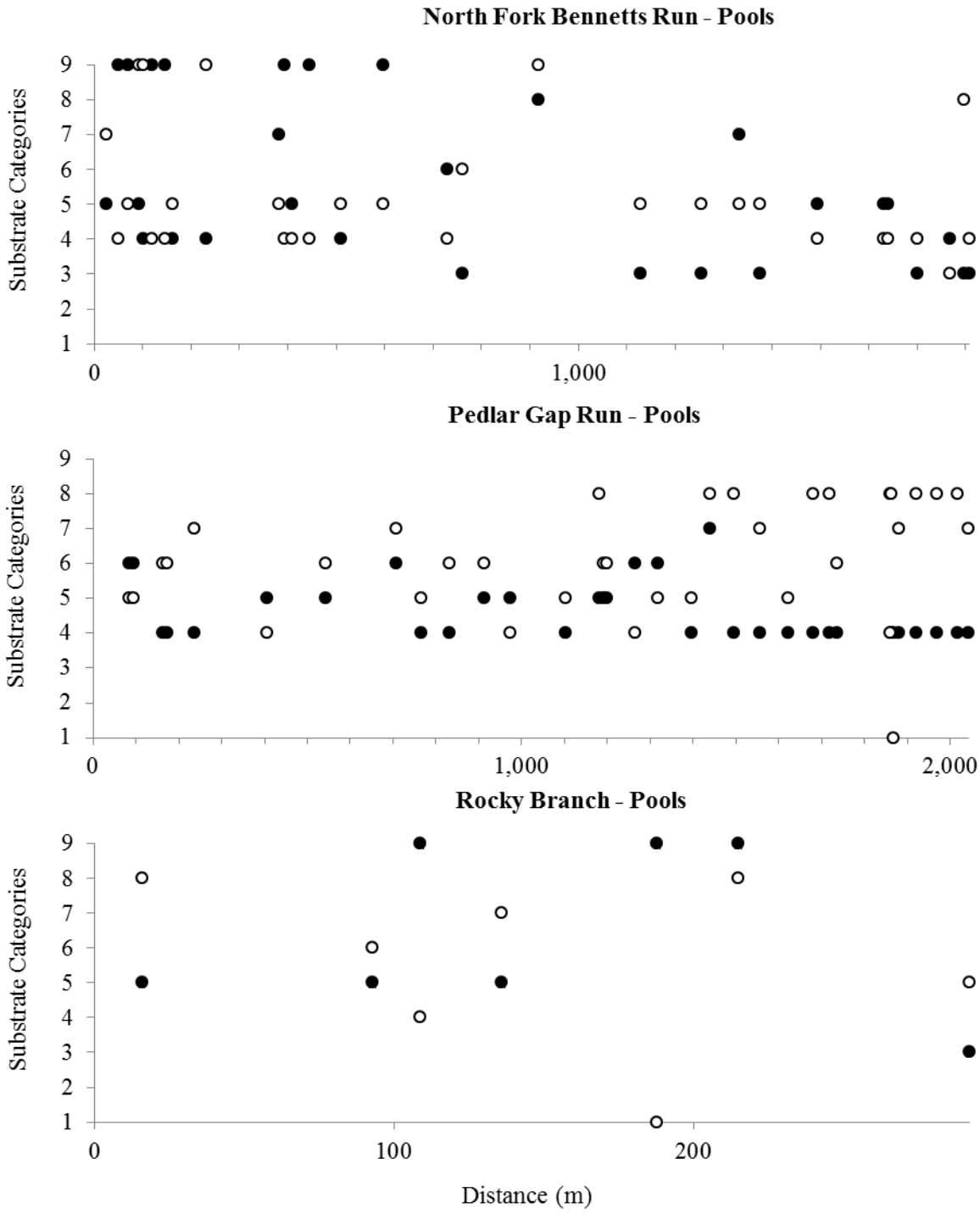


Figure C2 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in pools. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

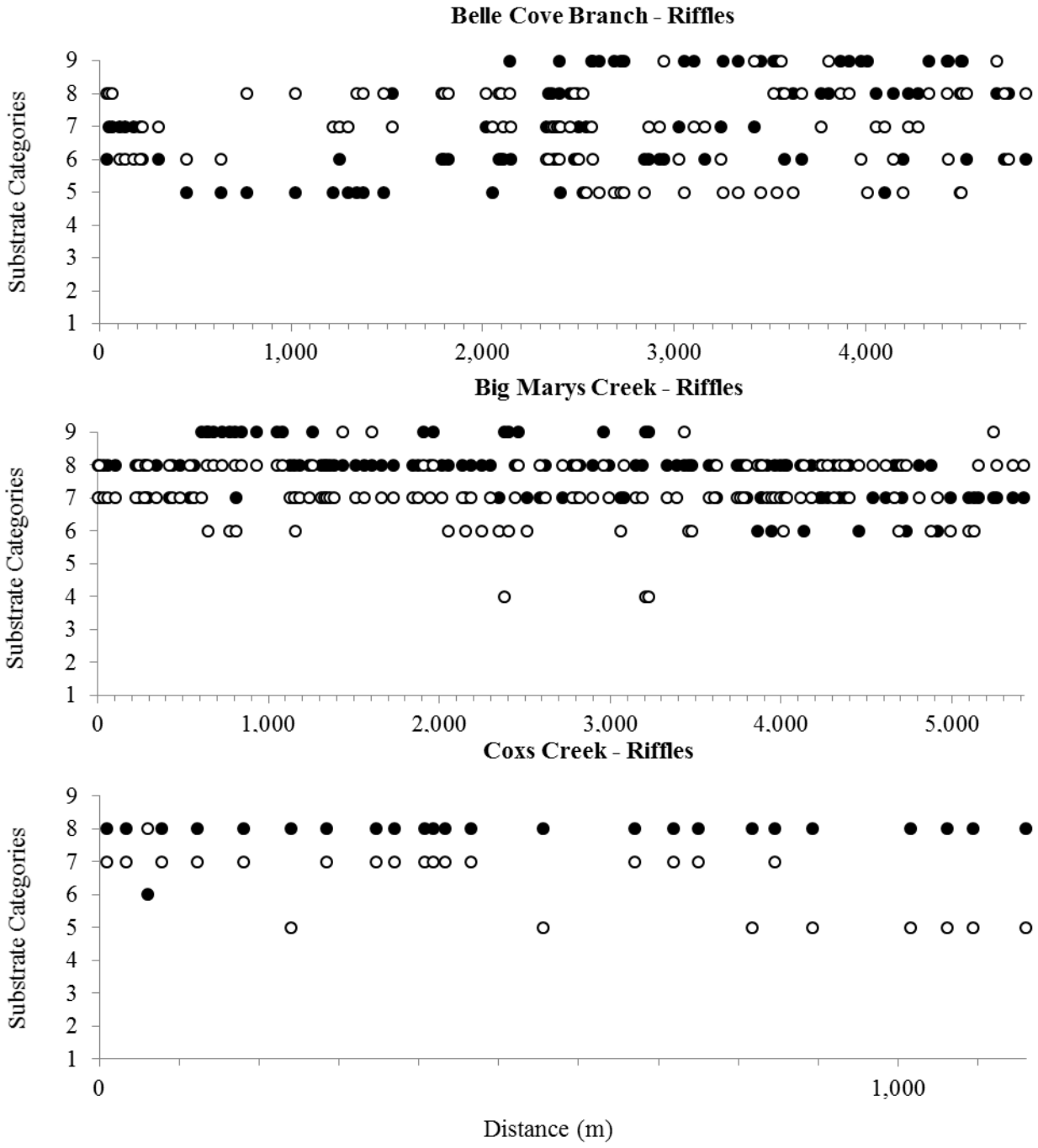


Figure C3. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

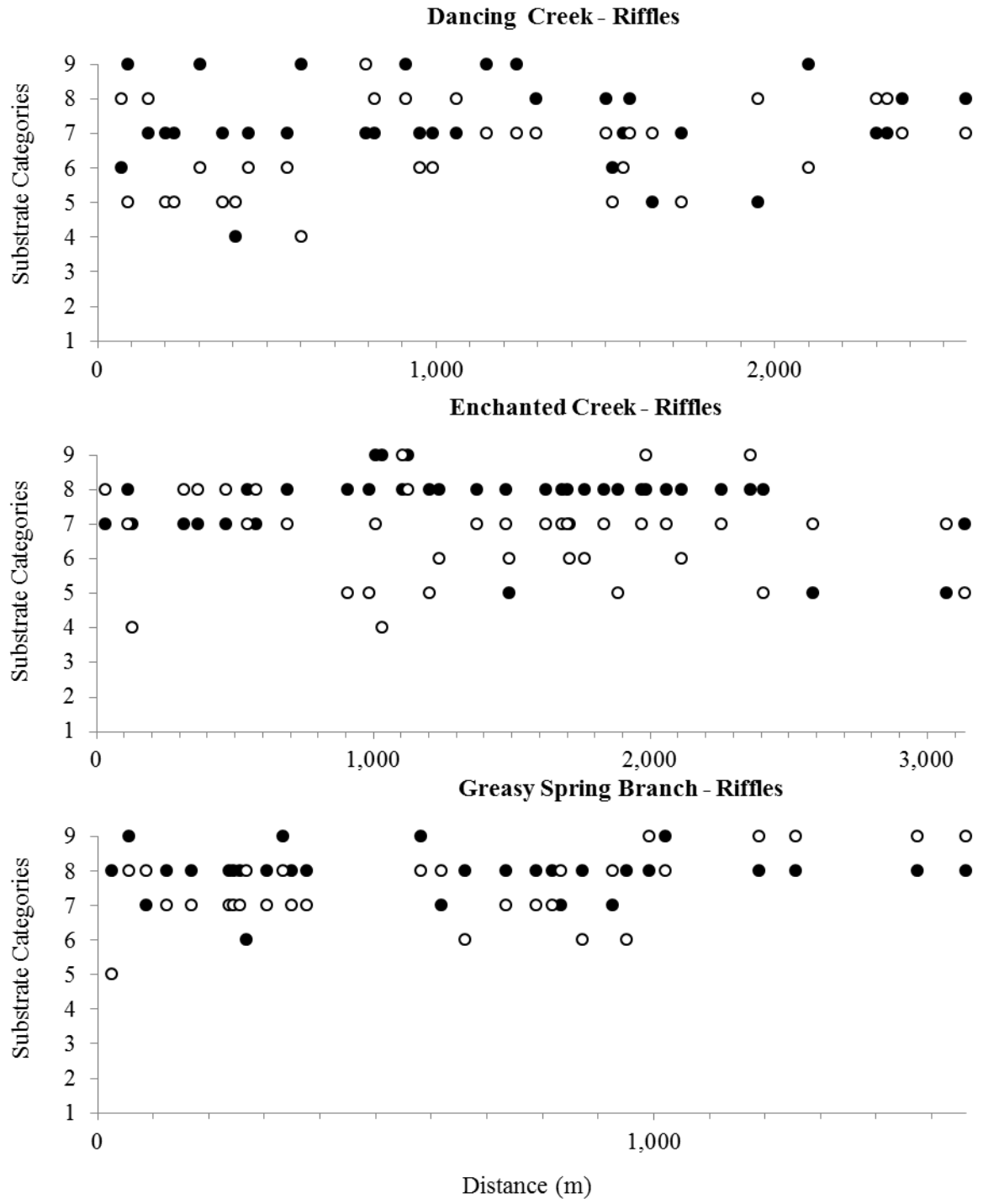


Figure C3 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

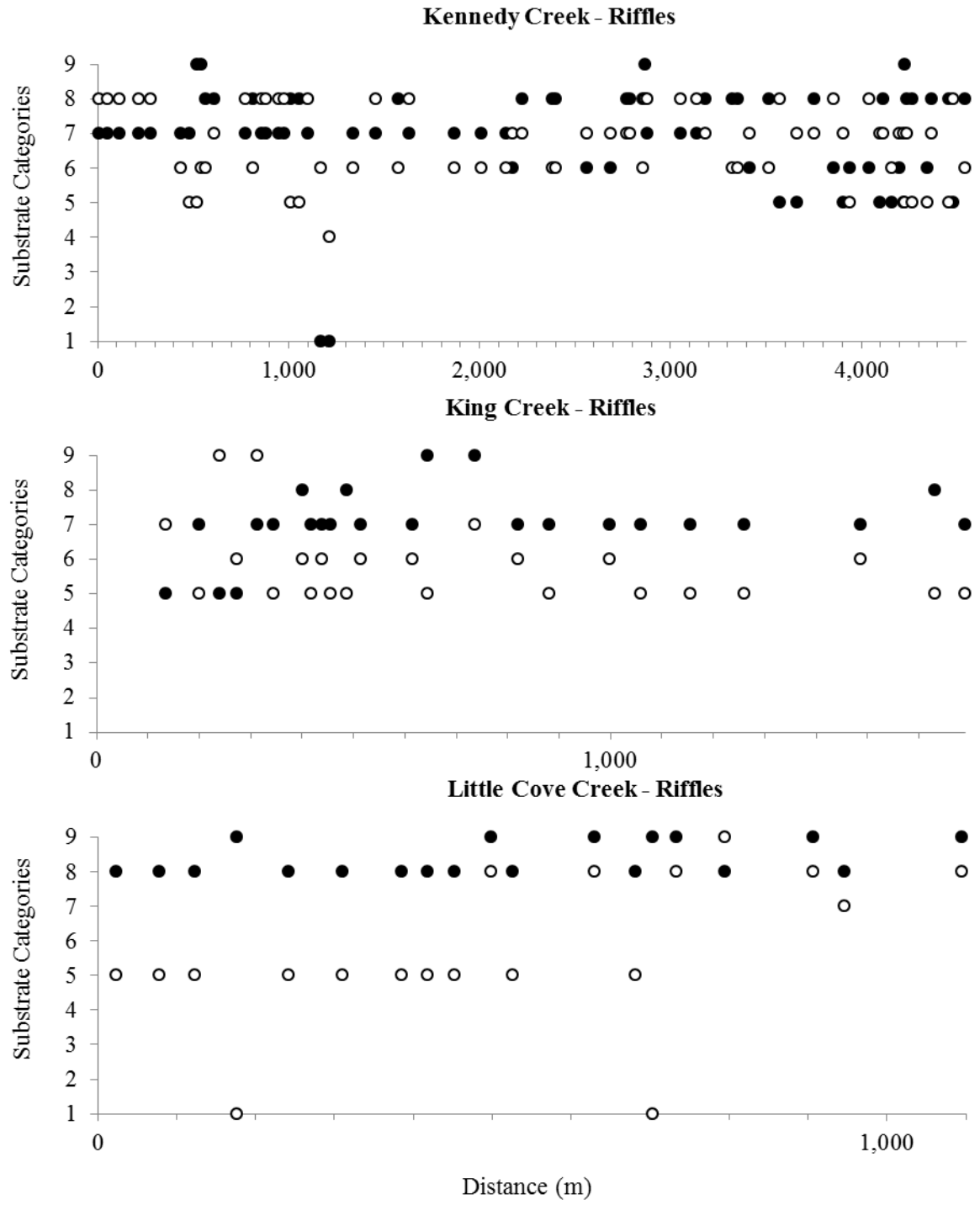


Figure C3 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

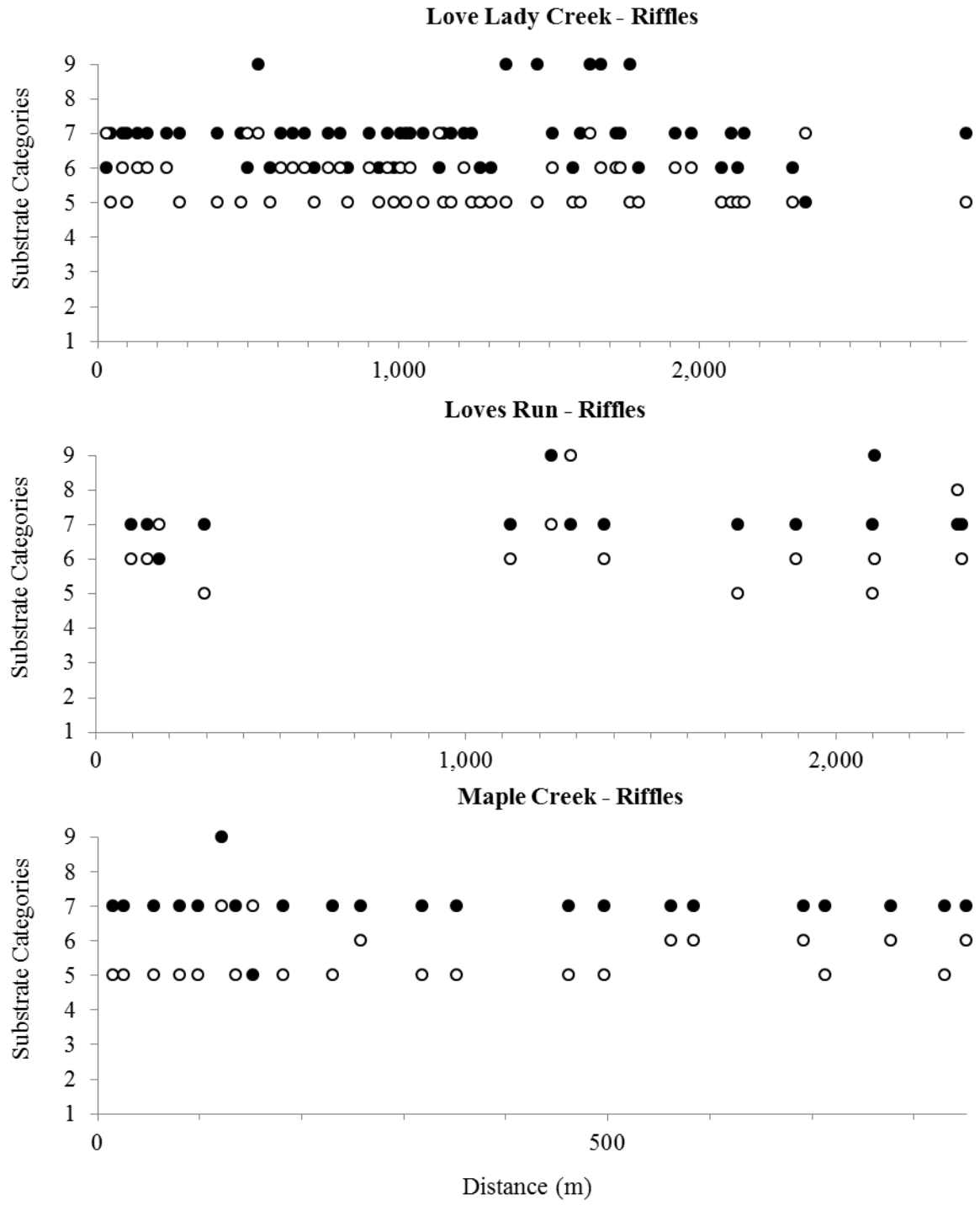


Figure C3 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

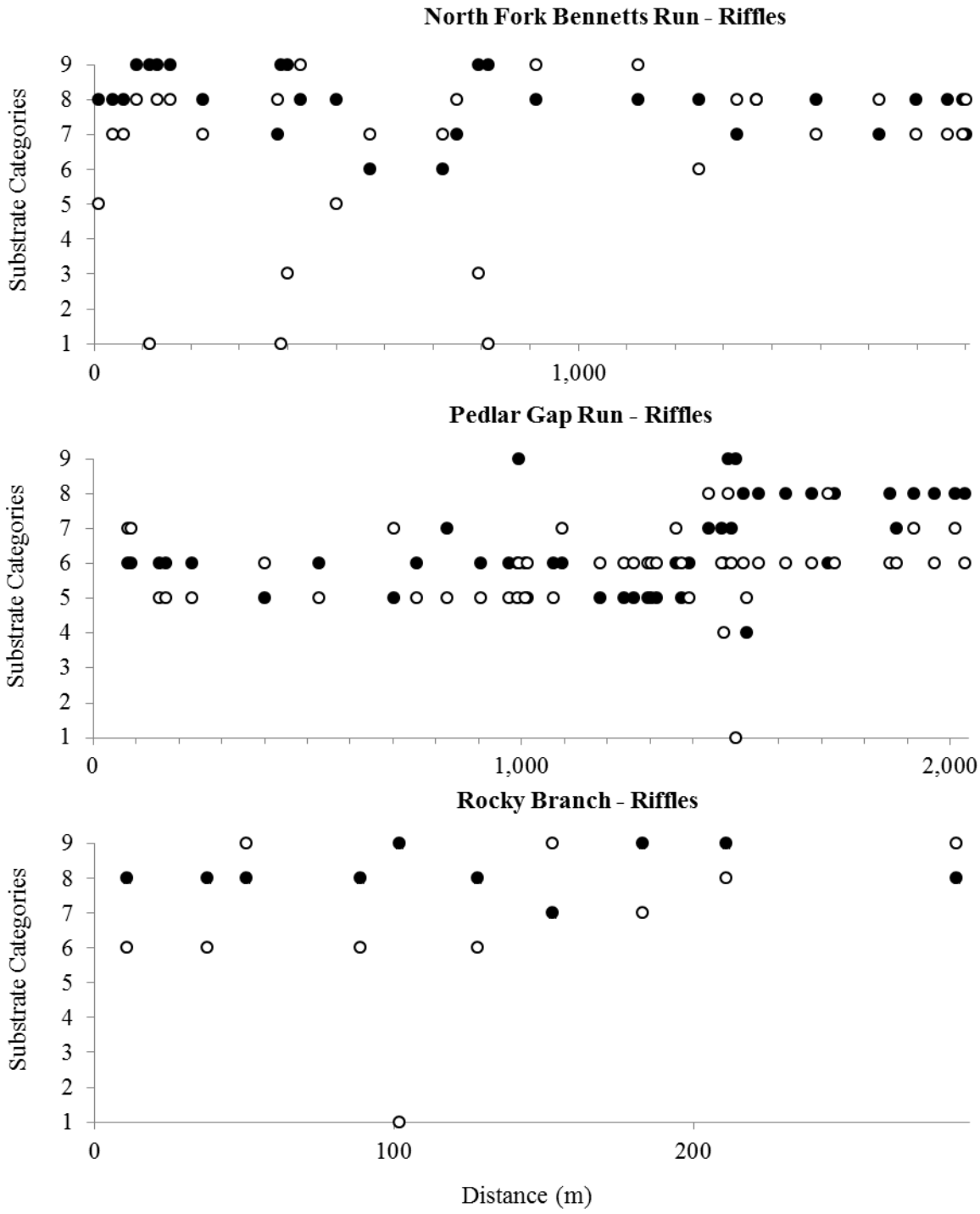


Figure C3 continued. Dominant (solid circles) and subdominant (open circles) substrate category present in riffles. Substrate size categories: 1 Organic Matter = dead leaves, detritus, etc.; 2 Clay = sticky, holds form; 3 Silt = slippery, doesn't hold form; 4 Sand = silt-2 mm; 5 Small Gravel = 3-16 mm; 6 Large Gravel = 17-64 mm; 7 Cobble = 65-256 mm; 8 Boulder = >256 mm; 9 Bedrock = solid rock.

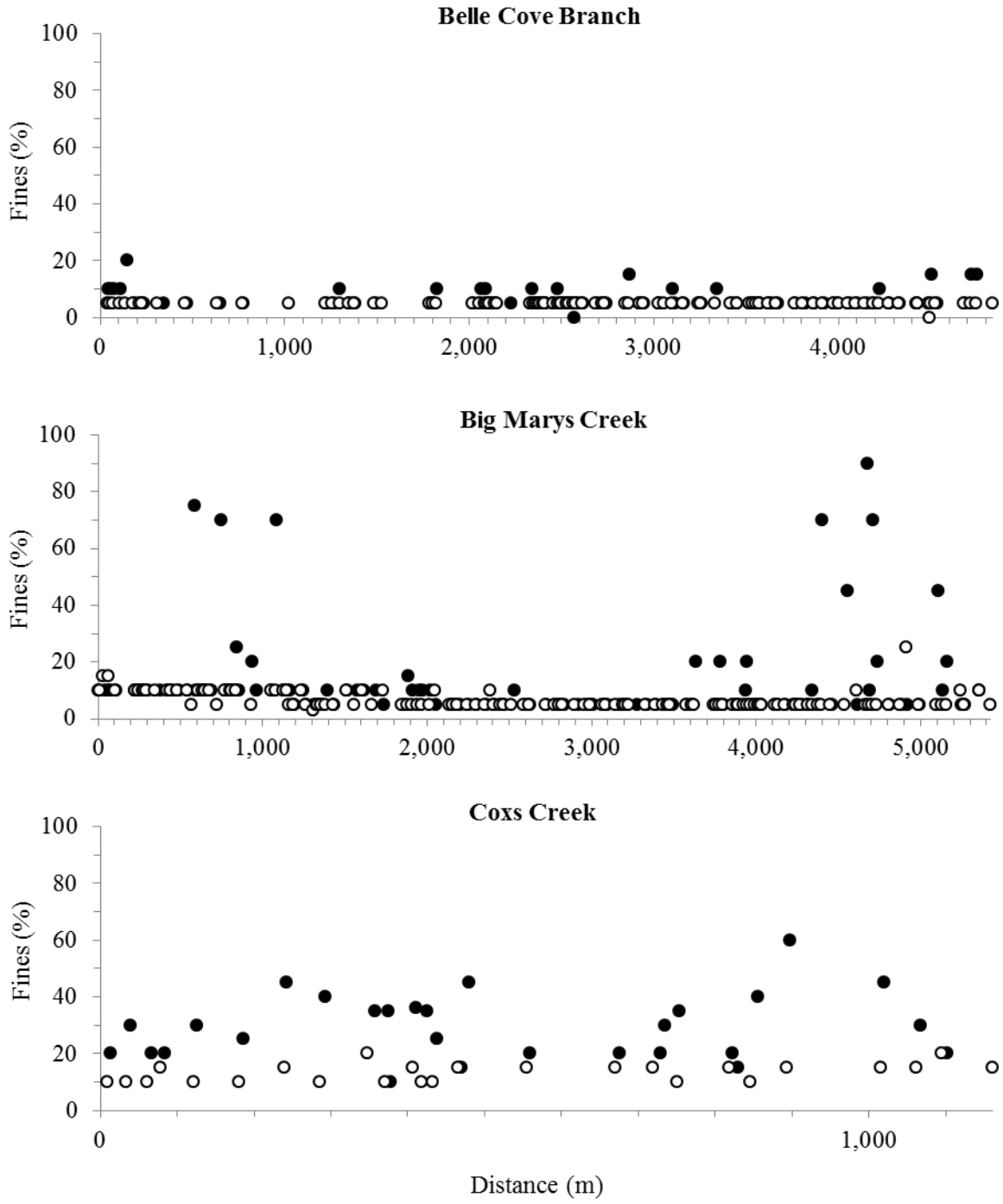


Figure C4. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

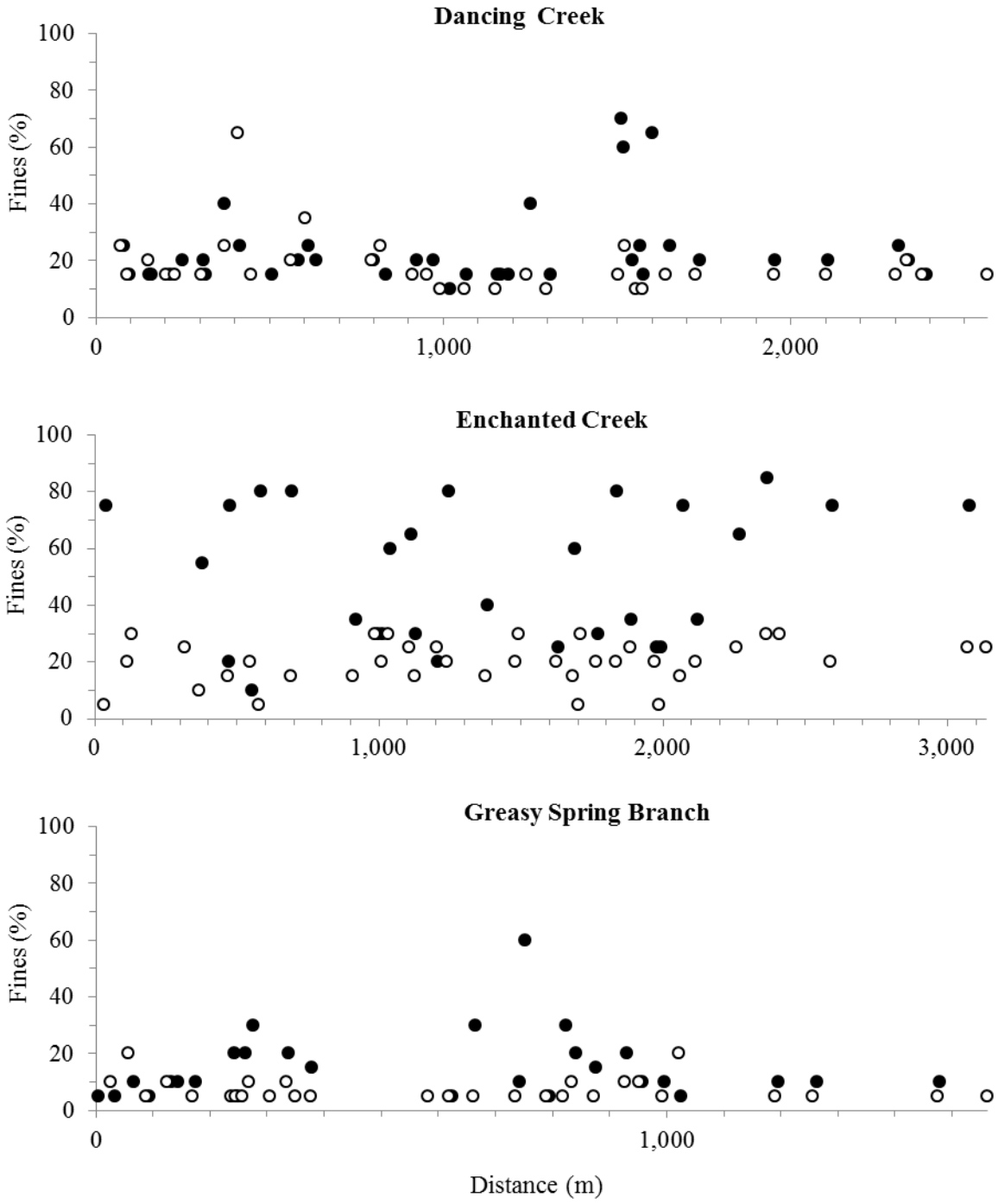


Figure C4 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

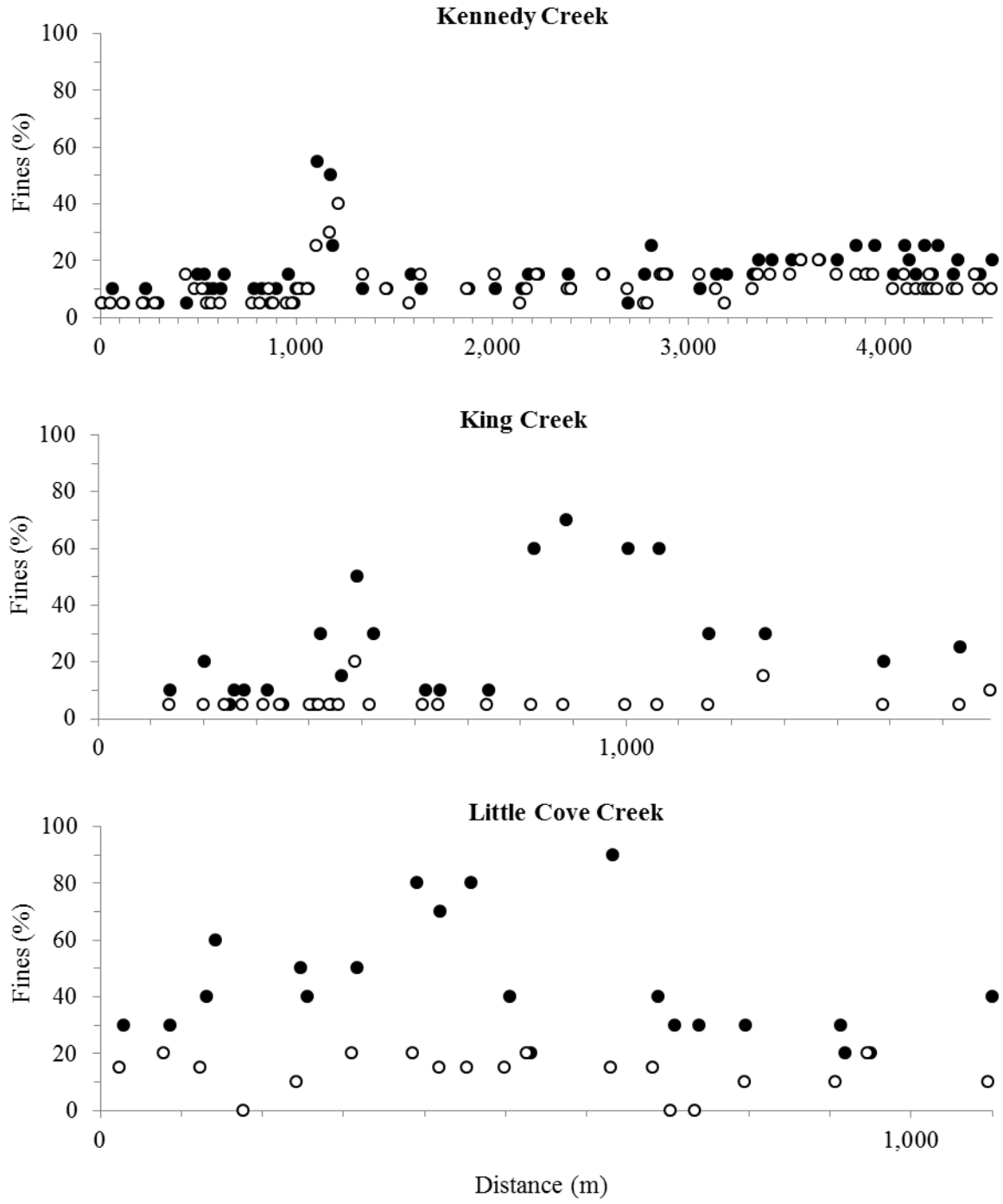


Figure C4 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

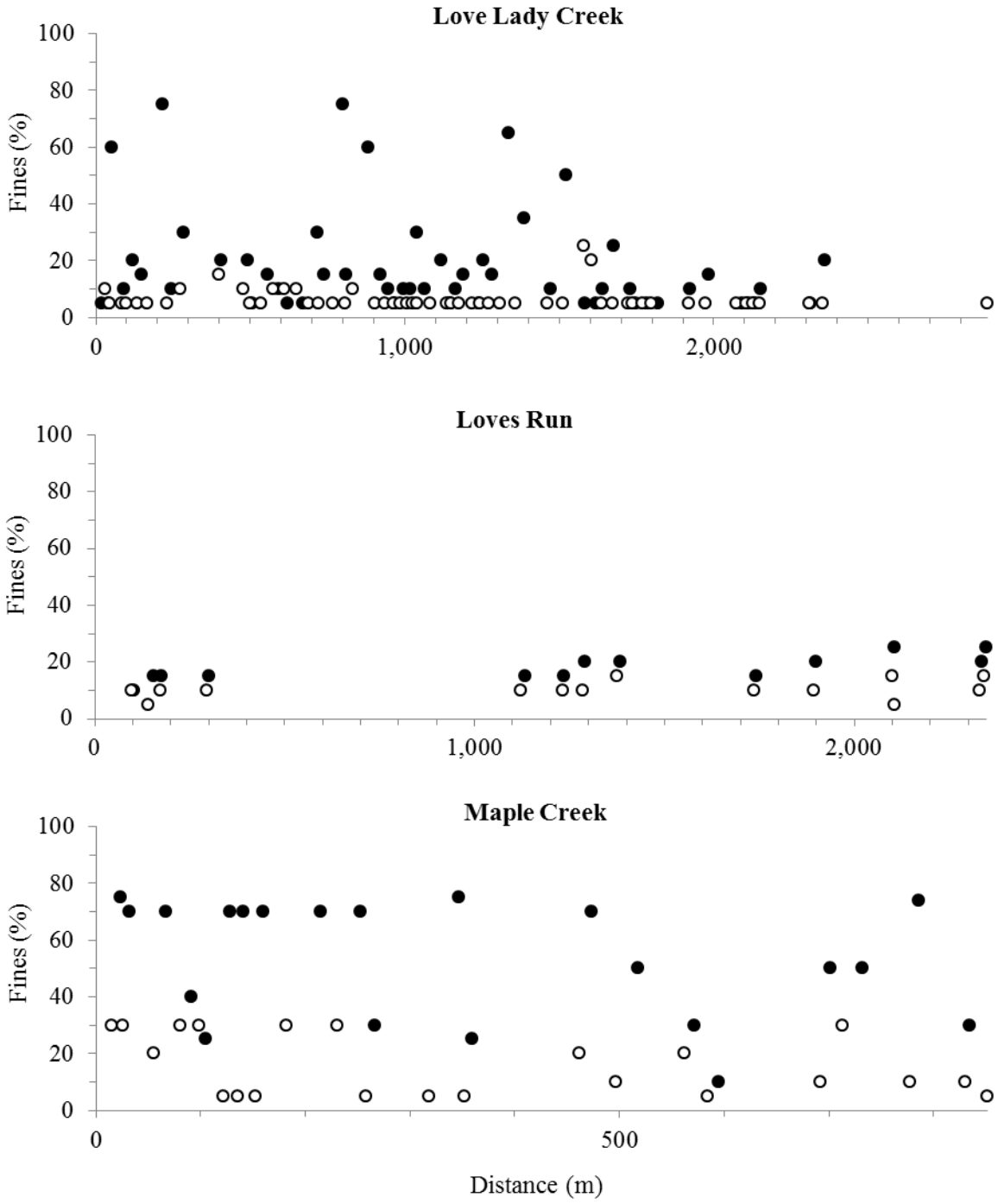


Figure C4 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

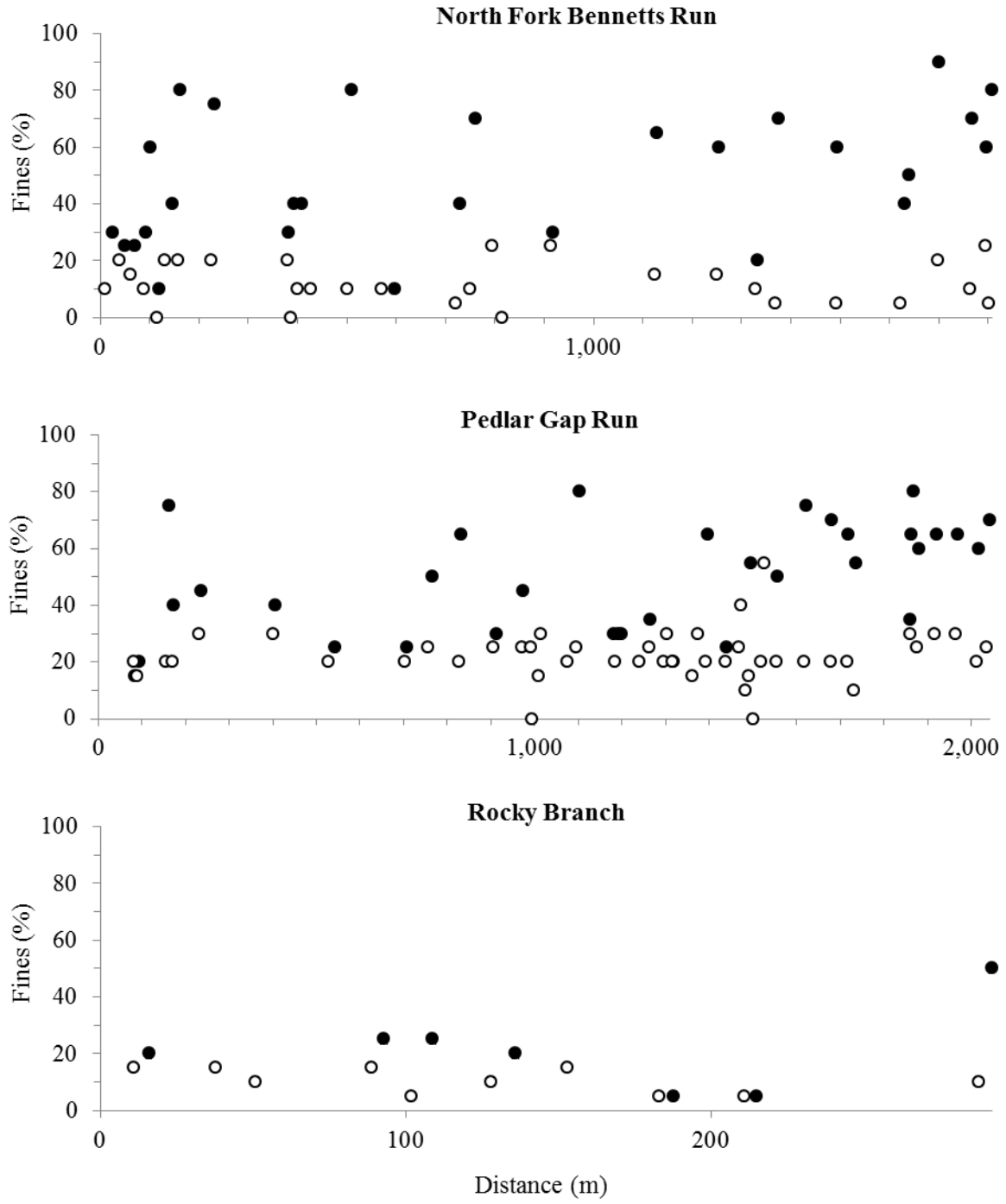


Figure C4 continued. Percent of each pool (solid circles) and riffle (open circles) channel bottom comprised of fine sediment (sand, silt, and/or clay).

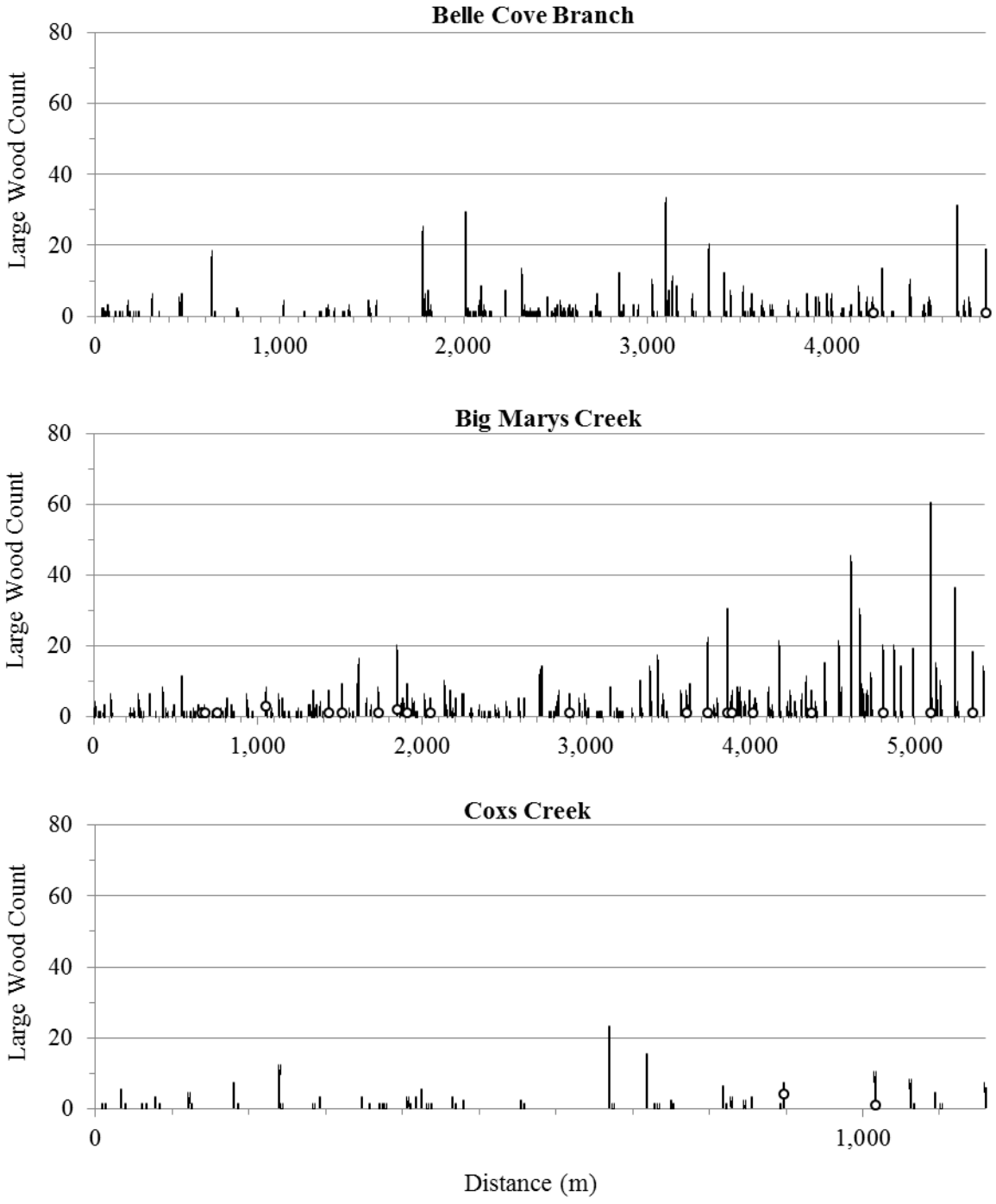


Figure C5. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units (pool, glide, riffle, run, cascade, and underground) in each stream inventoried. Belle Cove Br. LW n=476 and habitat unit n=193, Big Marys Cr. LW n=951 and habitat unit n=261, and Coxs Cr. LW n=120 and habitat unit n=53.

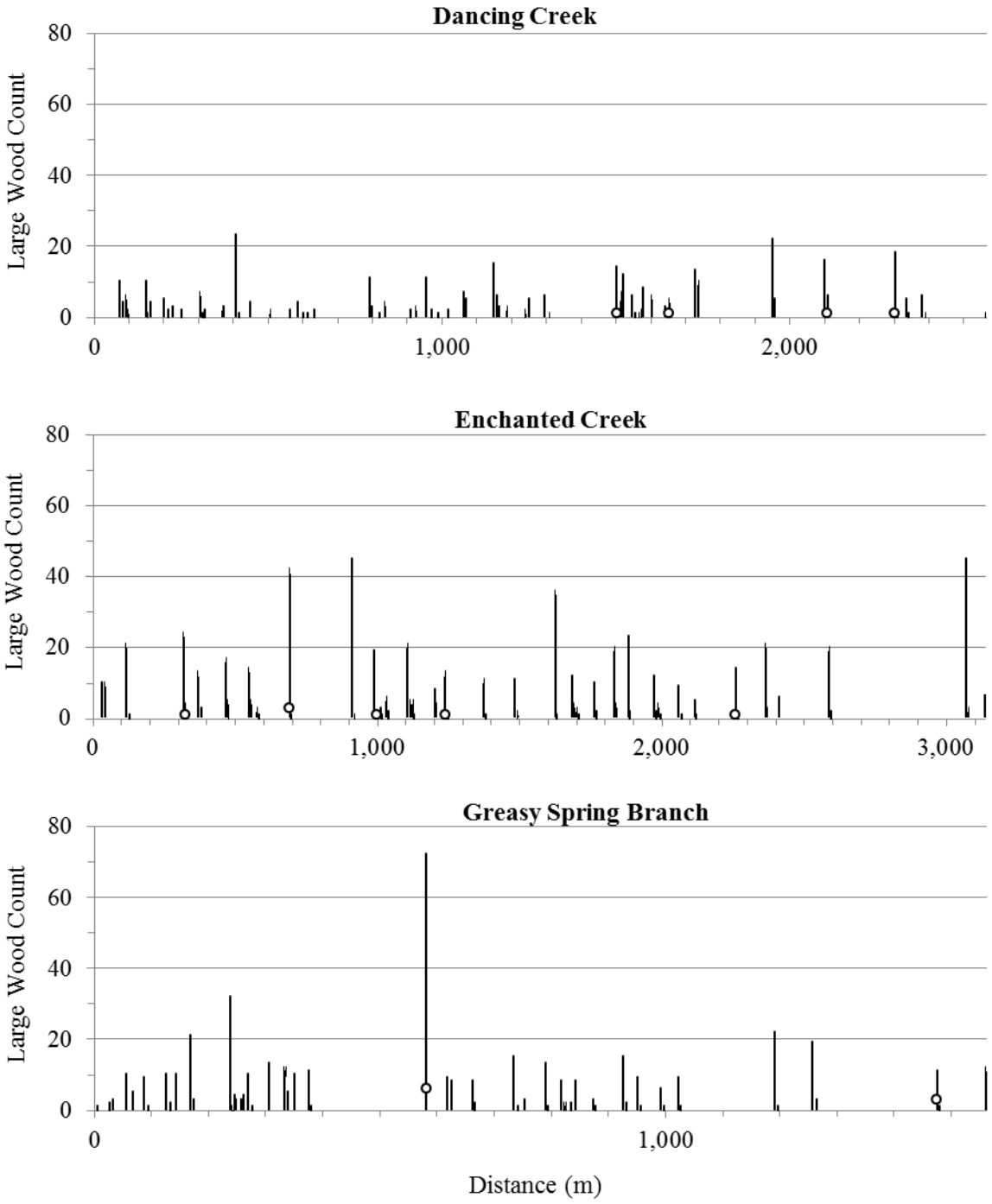


Figure C5 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units (pool, glide, riffle, run, cascade, and underground) in each stream inventoried. Dancing Cr. LW n=302 and habitat unit n=70, Enchanted Cr. LW n=546 and habitat unit n=67, and Greasy Spring Br. LW n=399 and habitat unit n=57.

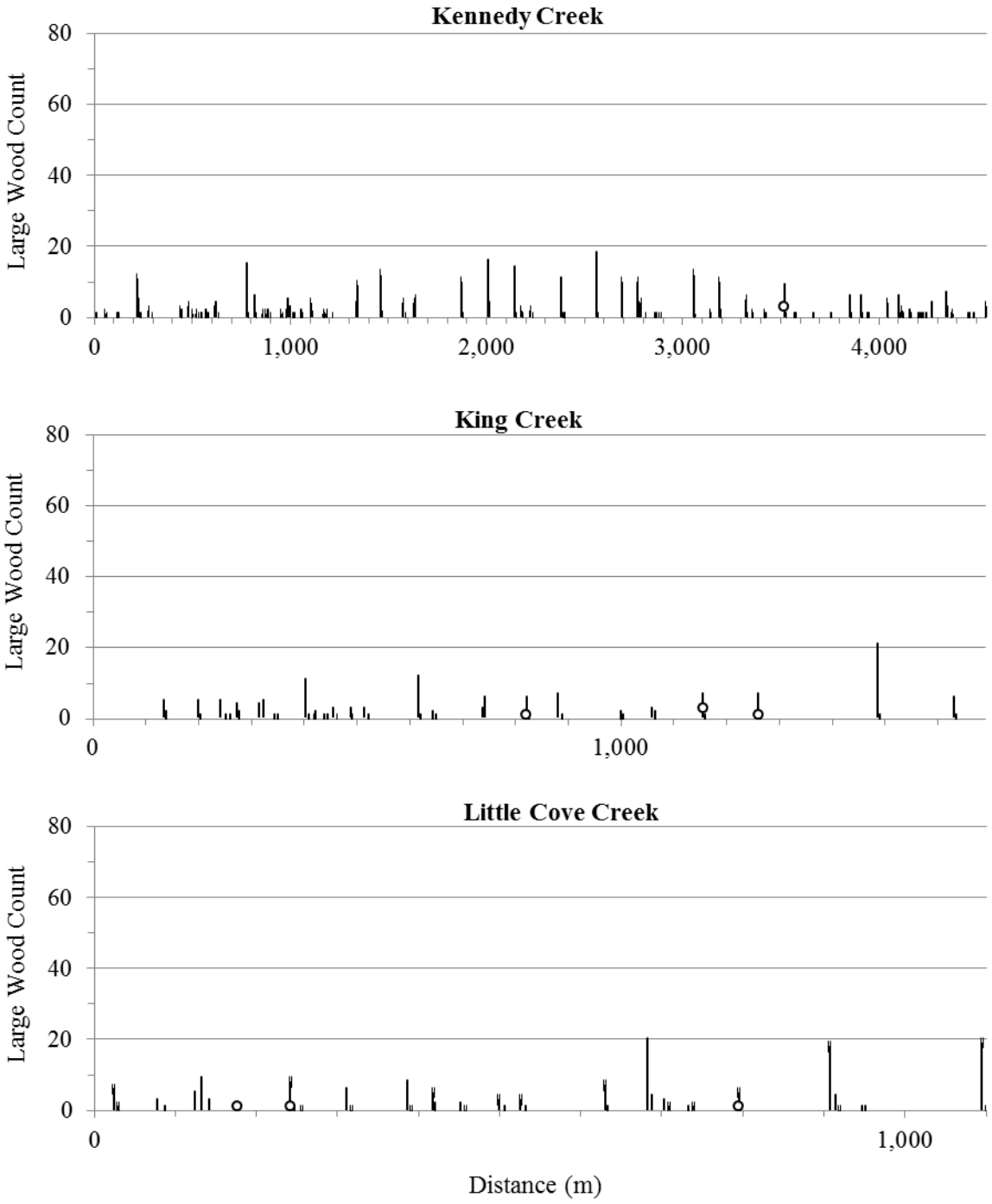


Figure C5 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units (pool, glide, riffle, run, cascade, and underground) in each stream inventoried. Kennedy Cr. LW n=287 and habitat unit n=133, King Cr. LW n=112 and habitat unit n=48, and Little Cove Cr. LW n=135 and habitat unit n=40.

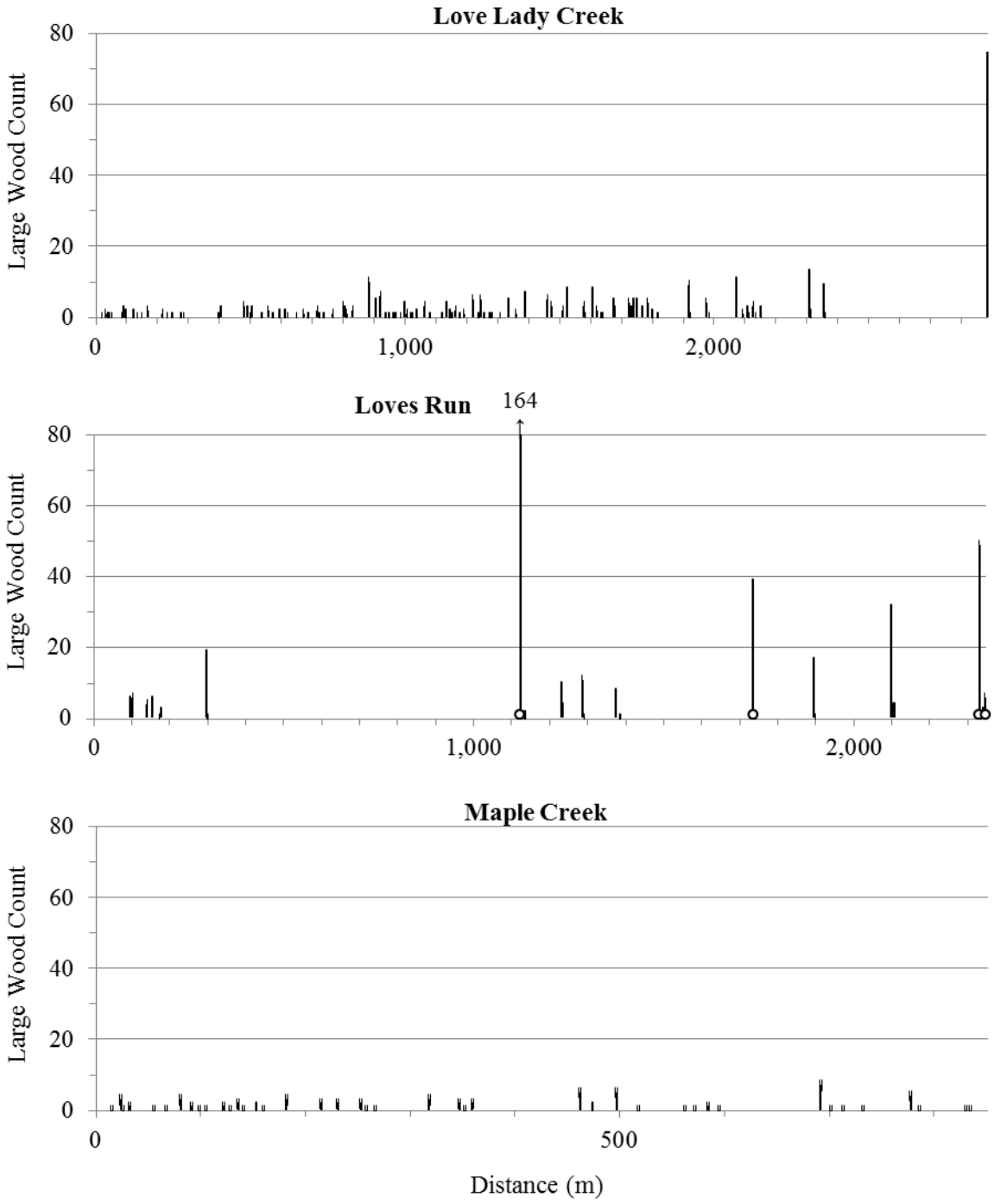


Figure C5 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units (pool, glide, riffle, run, cascade, and underground) in each stream inventoried. Love Lady Cr. LW n=273 and habitat unit n=110, Loves Run LW n=384 and habitat unit n=27, and Maple Cr. LW n=51 and habitat unit n=43.

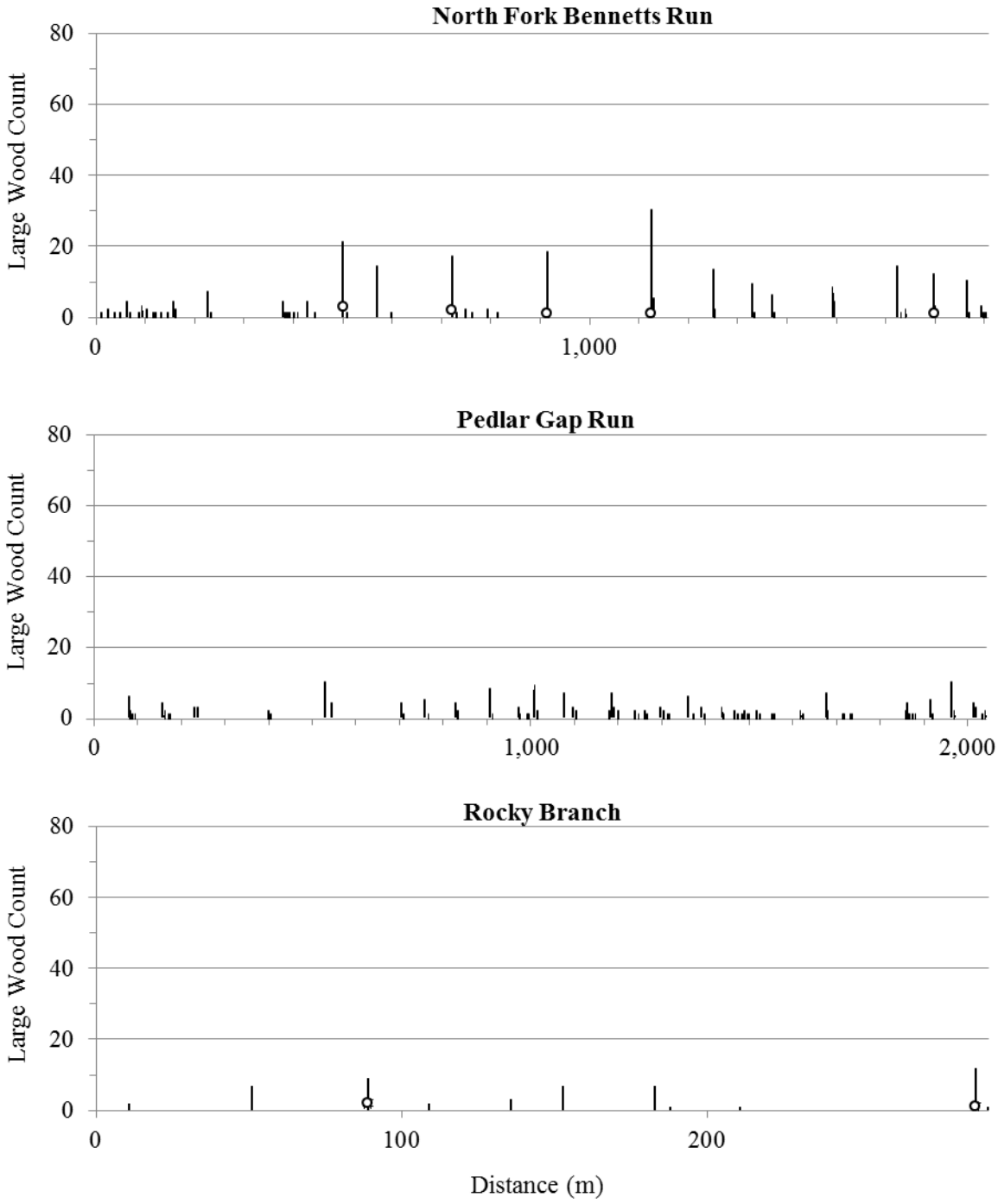


Figure C5 continued. Count of large wood (bars = size classes 1, 2, 3, 4, and rootwad combined; open circles = size 4 only) within individual habitat units (pool, glide, riffle, run, cascade, and underground) in each stream inventoried. North Fork Bennetts Run LW n=198 and habitat unit n=58, Pedlar Gap Run LW n=124 and habitat unit n=81, and Rocky Branch LW n=52 and habitat unit n=17.

Appendix D: Large wood count for 1995, 2005, and 2015 stream inventories

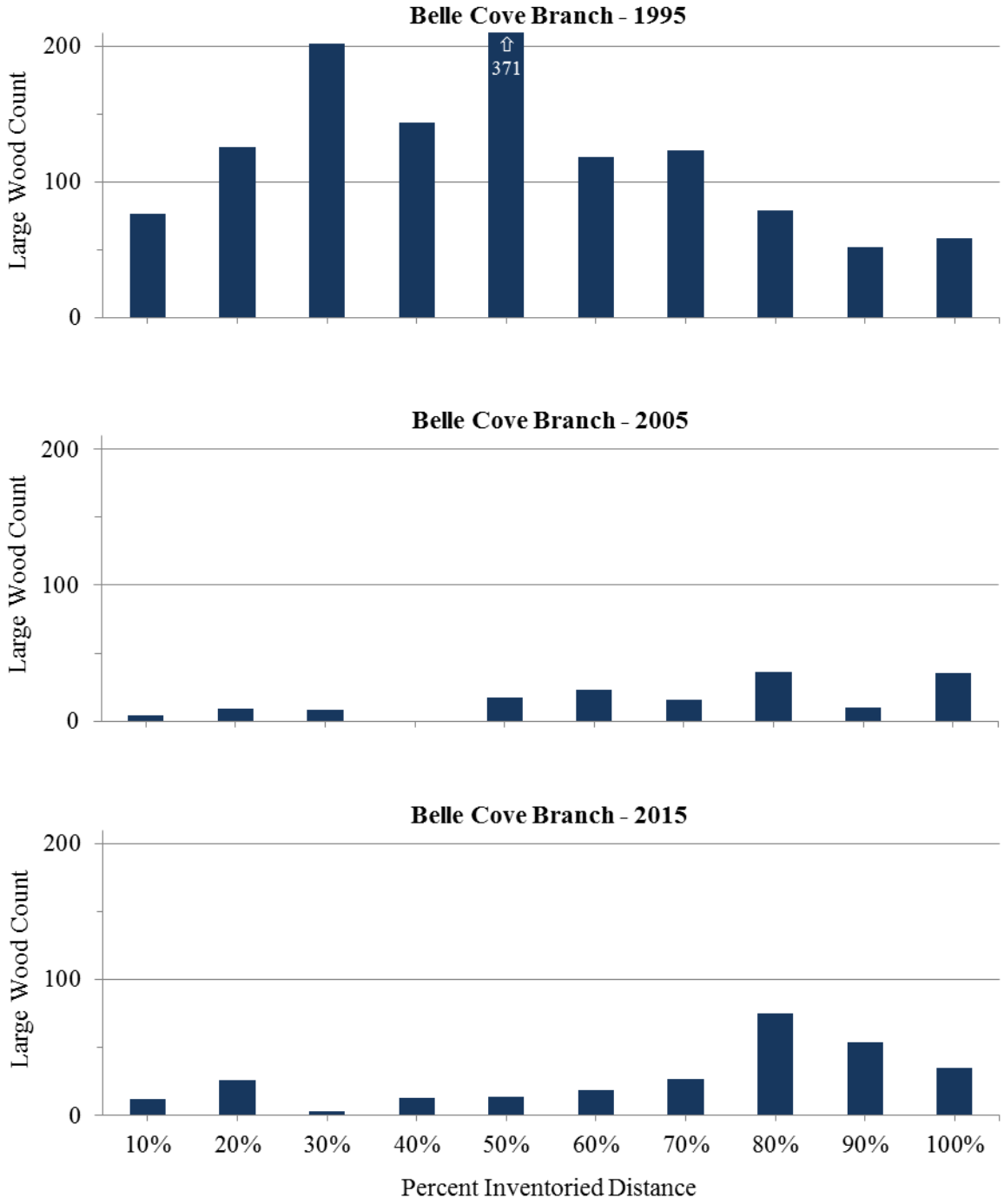


Figure D1. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Belle Cove Branch. 1995 LW n=1351 and habitat unit n=171, 2005 LW n=158 and habitat unit n=146, and 2015 LW n=278 and habitat unit n=155.

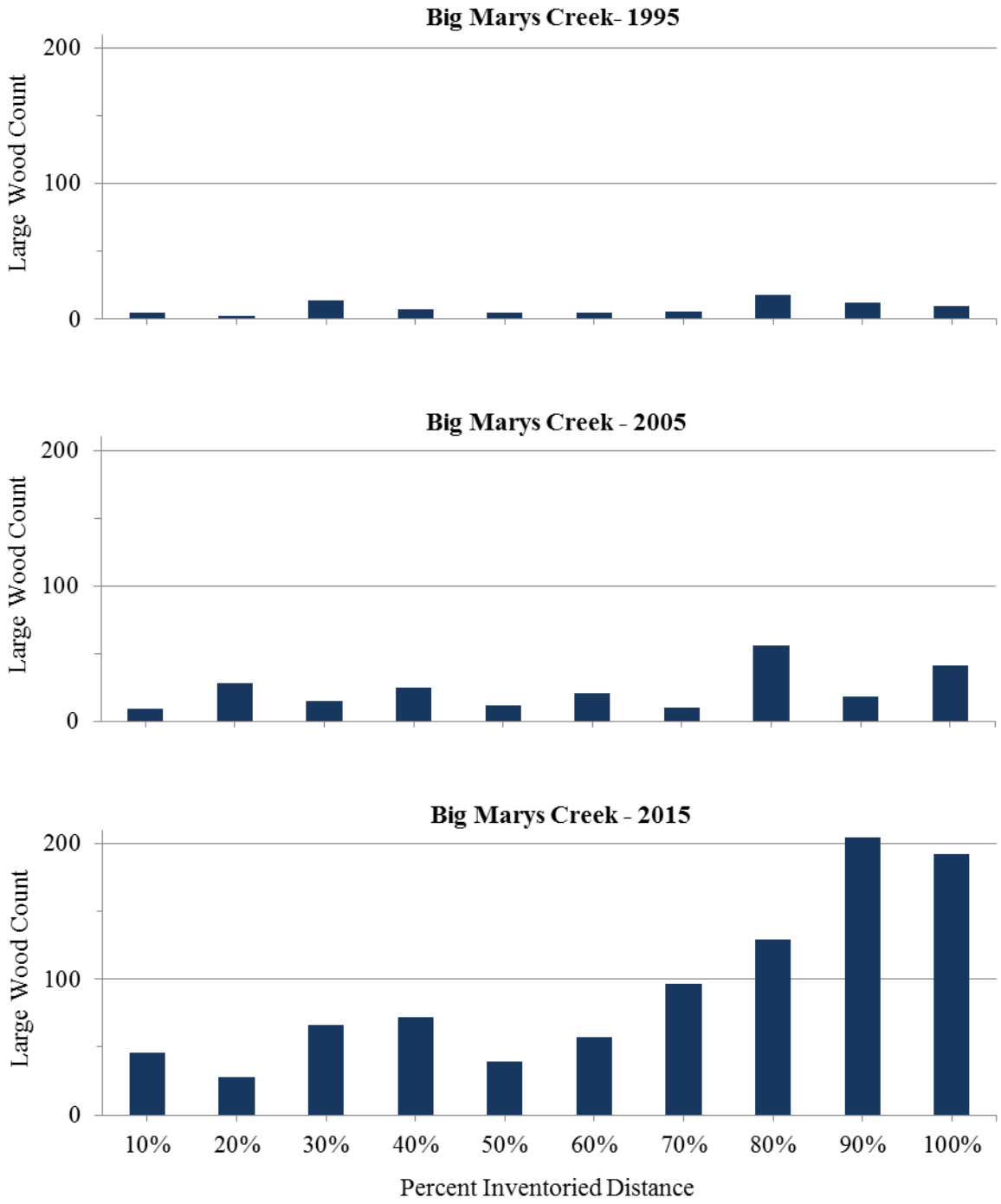


Figure D2. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Big Marys Creek. 1995 LW n=84 and habitat unit n=354, 2005 LW n=235 and habitat unit n=177, and 2015 LW n=931 and habitat unit n=261.

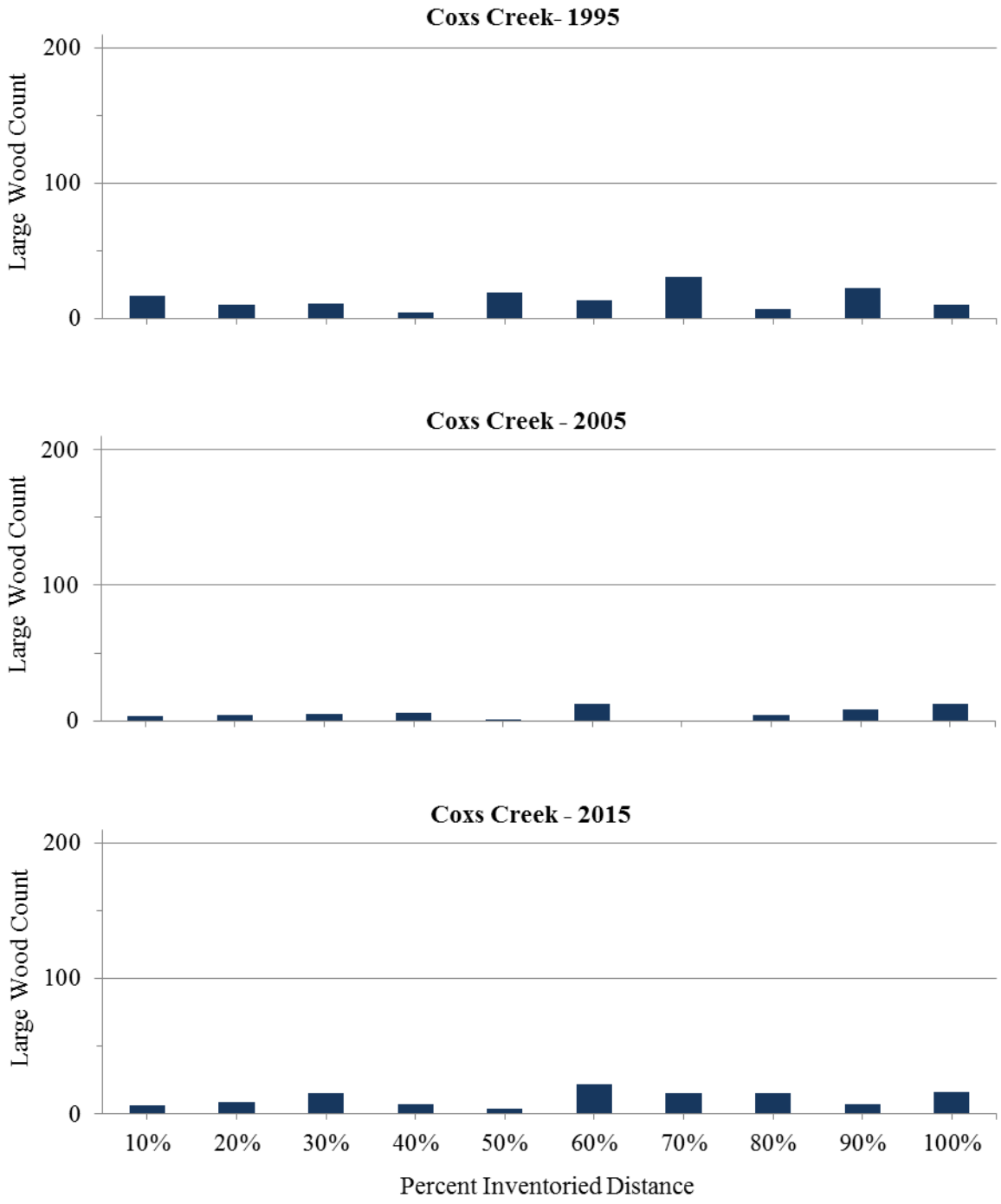


Figure D3. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Coxs Creek. 1995 LW n=147 and habitat unit n=231, 2005 LW n=55 and habitat unit n=85, and 2015 LW n=116 and habitat unit n=53.

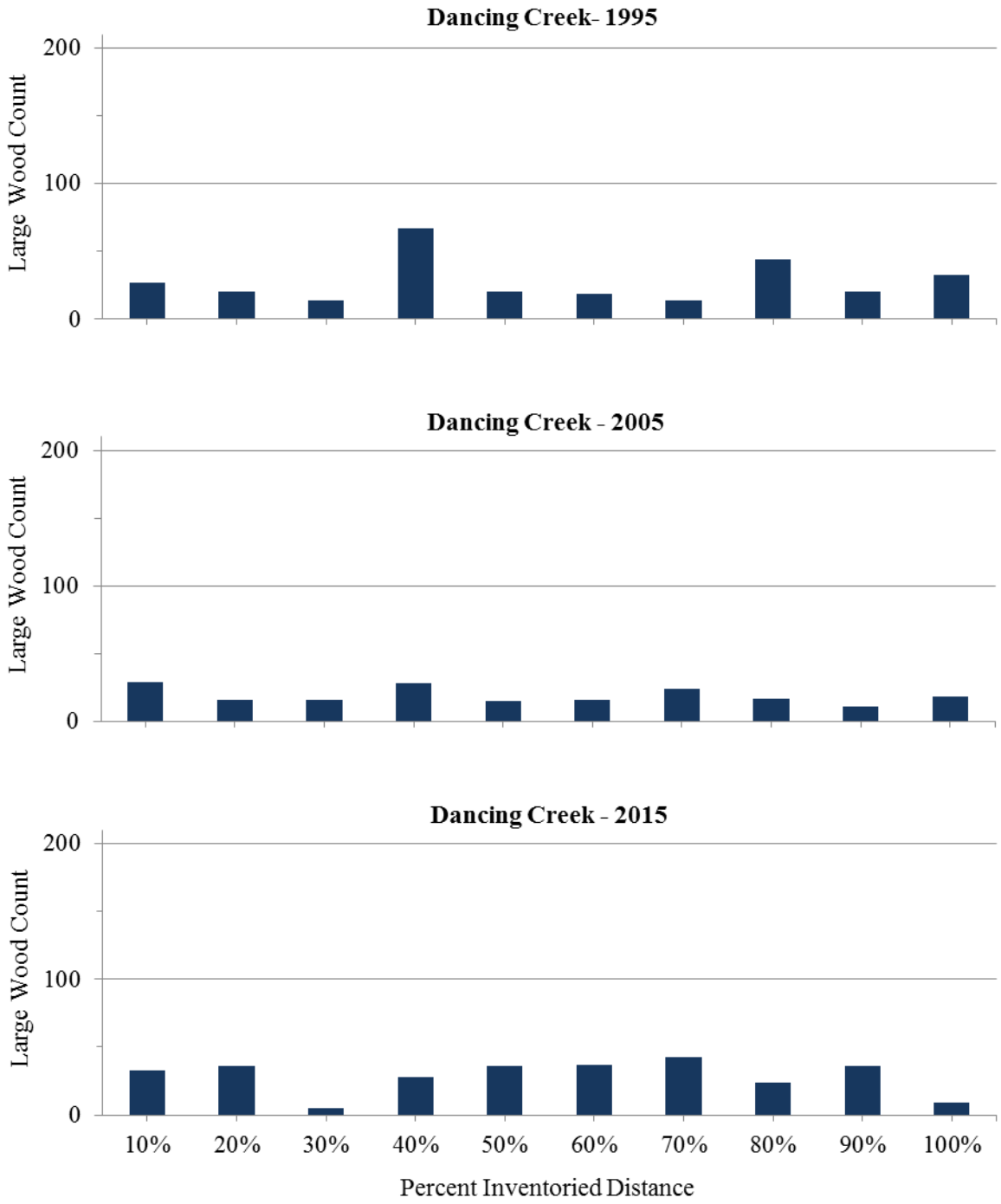


Figure D4. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Dancing Creek. 1995 LW n=278 and habitat unit n=210, 2005 LW n=190 and habitat unit n=155, and 2015 LW n=287 and habitat unit n=70.

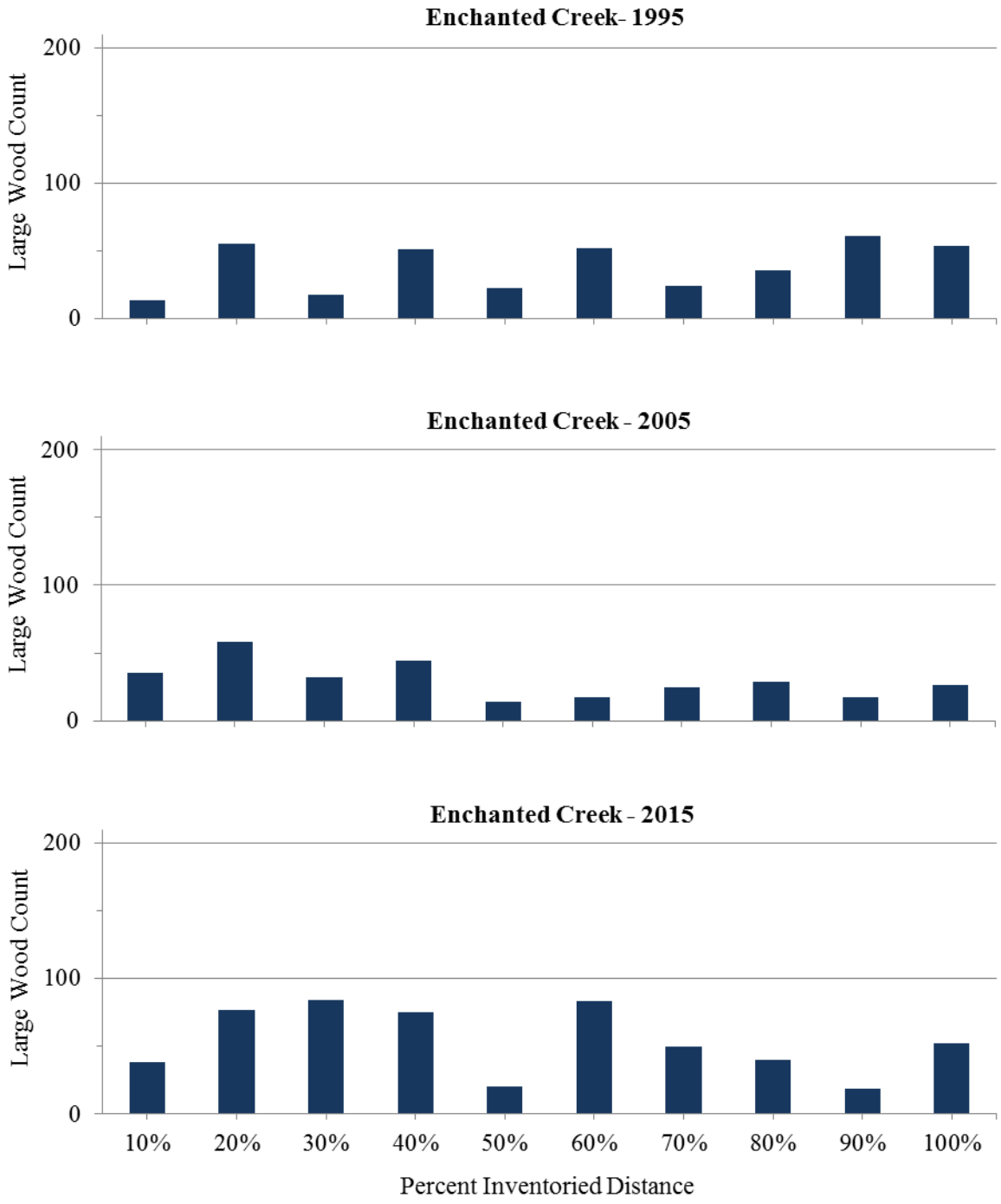


Figure D5. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Enchanted Creek. 1995 LW n=388 and habitat unit n=407, 2005 LW n=297 and habitat unit n=142, and 2015 LW n=538 and habitat unit n=67.

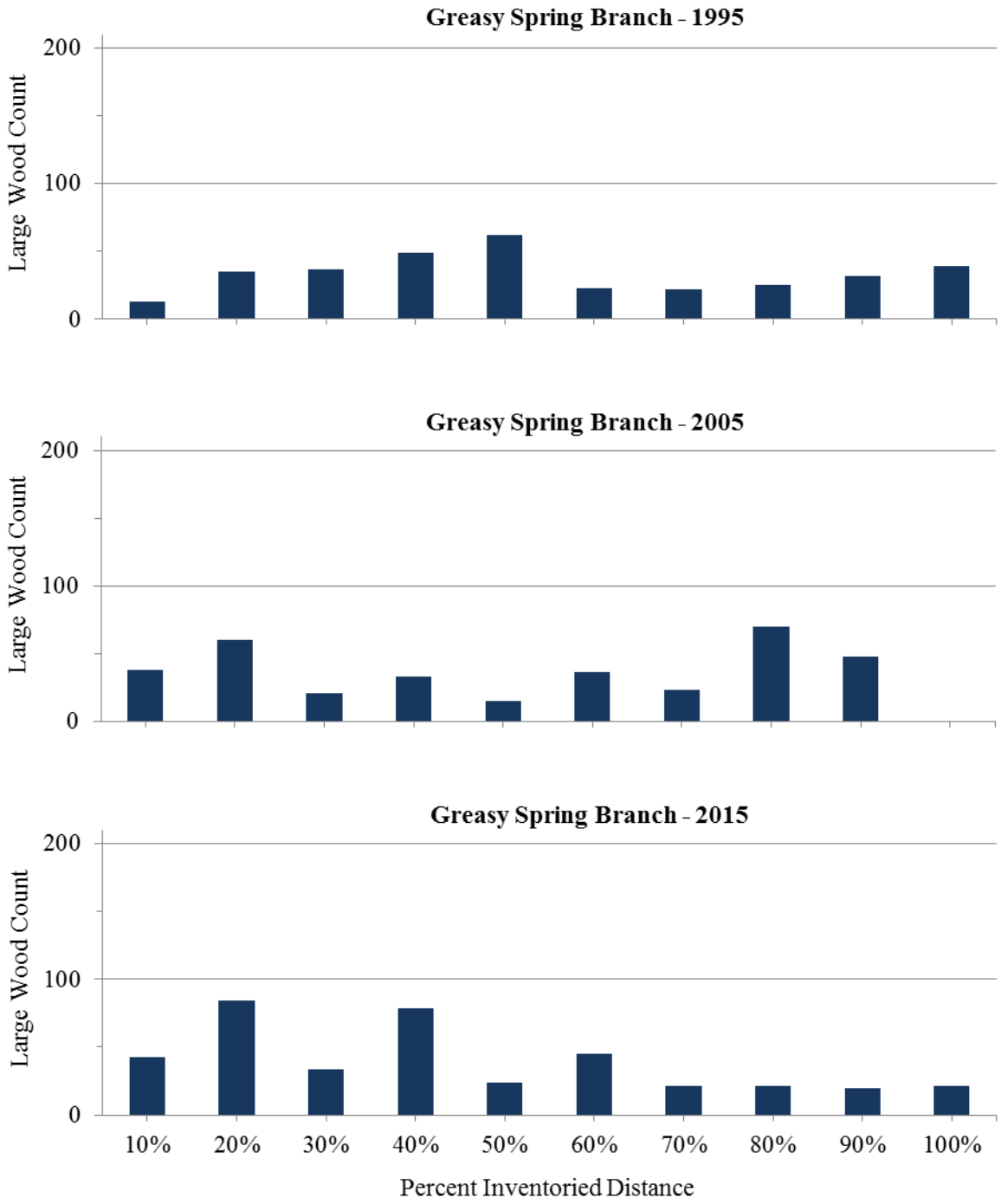


Figure D6. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Greasy Spring Branch. 1995 LW n=337 and habitat unit n=154, 2005 LW n=344 and habitat unit n=149, and 2015 LW n=392 and habitat unit n=57.

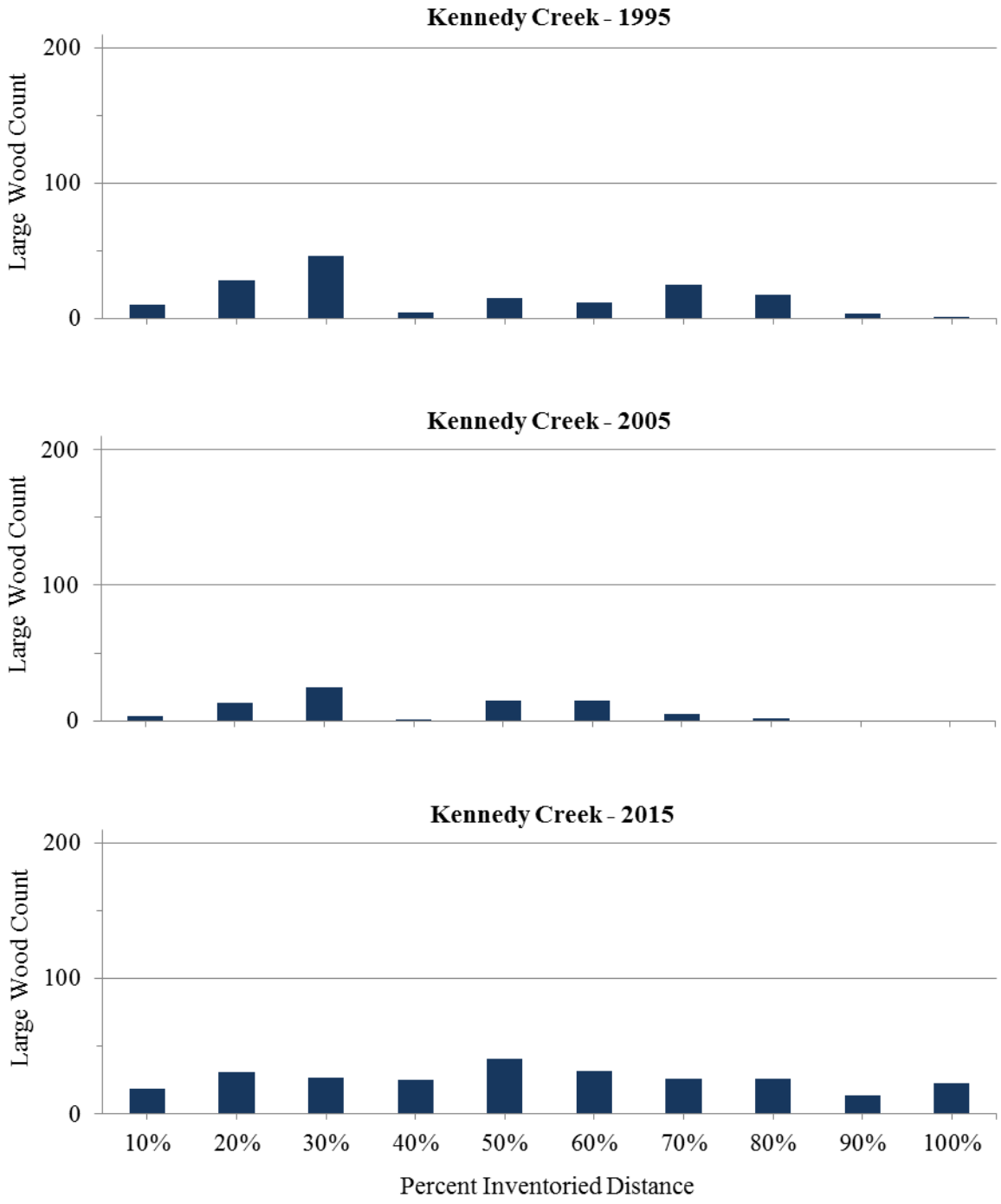


Figure D7. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Kennedy Creek. 1995 LW n=164 and habitat unit n=402, 2005 LW n=79 and habitat unit n=230, and 2015 LW n=264 and habitat unit n=133.

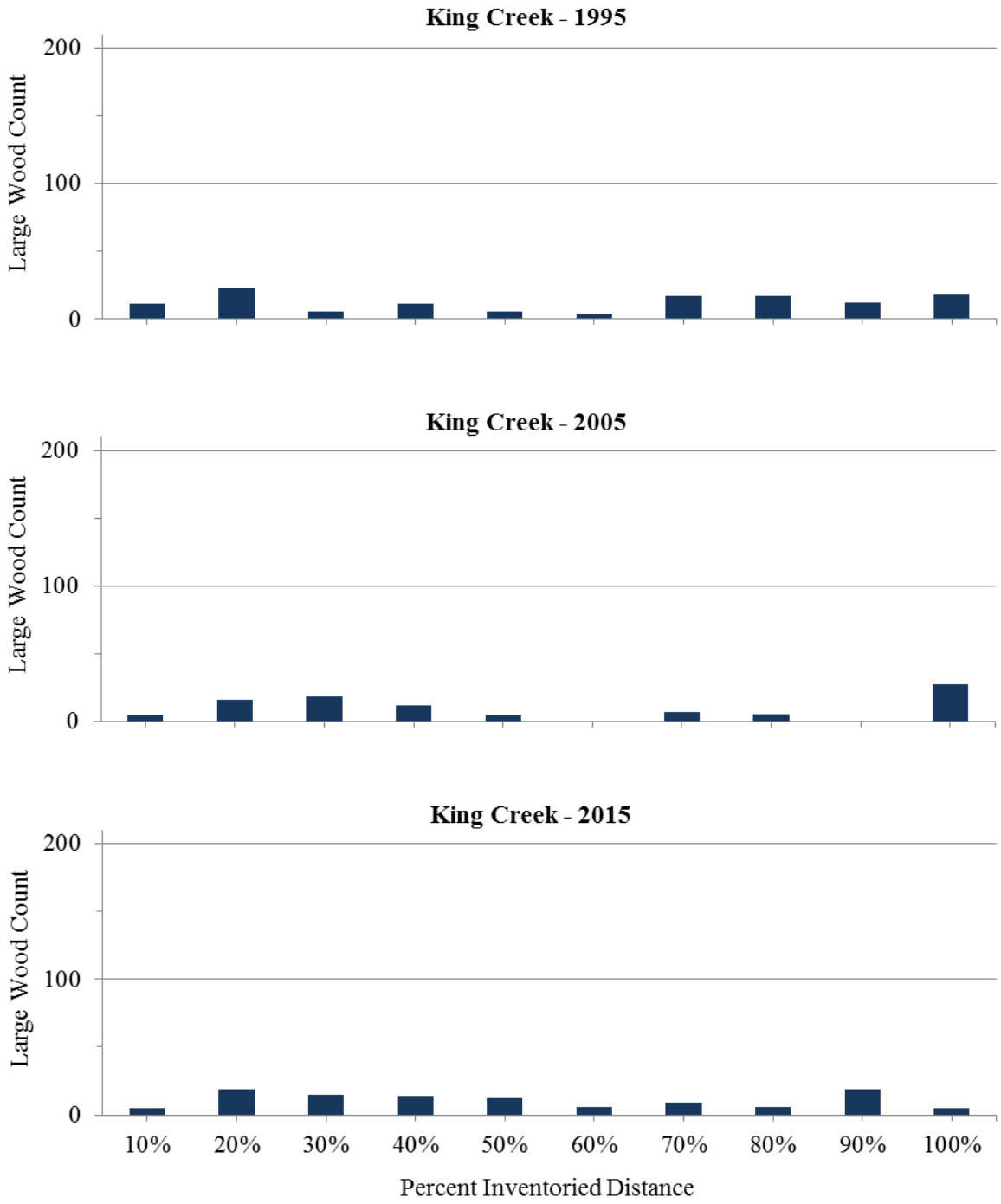


Figure D8. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in King Creek. 1995 LW n=126 and habitat unit n=214, 2005 LW n=93 and habitat unit n=101, and 2015 LW n=110 and habitat unit n=48.

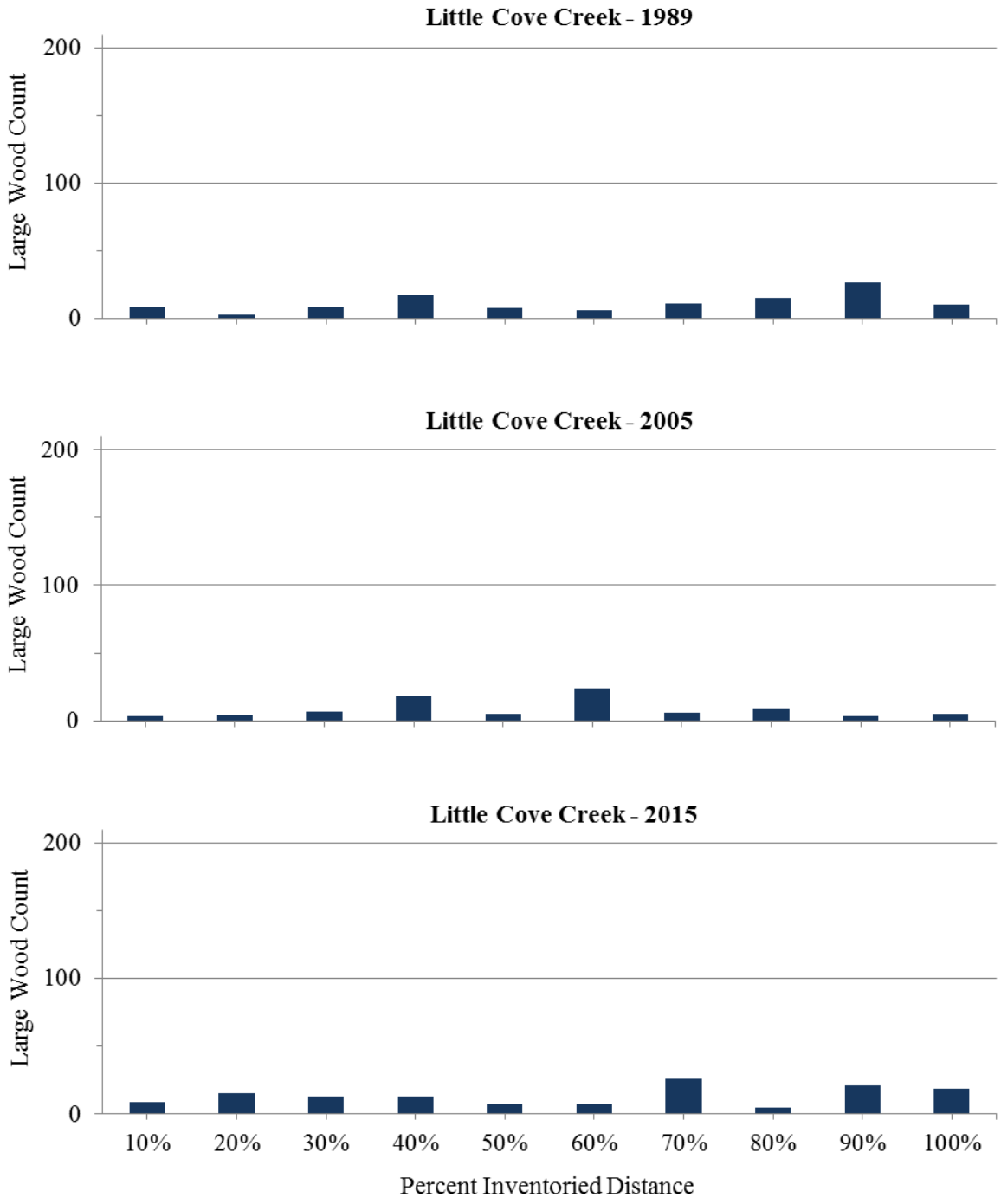


Figure D9. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Little Cove Creek. 1995 LW n=116 and habitat unit n=160, 2005 LW n=84 and habitat unit n=100, and 2015 LW n=135 and habitat unit n=40.

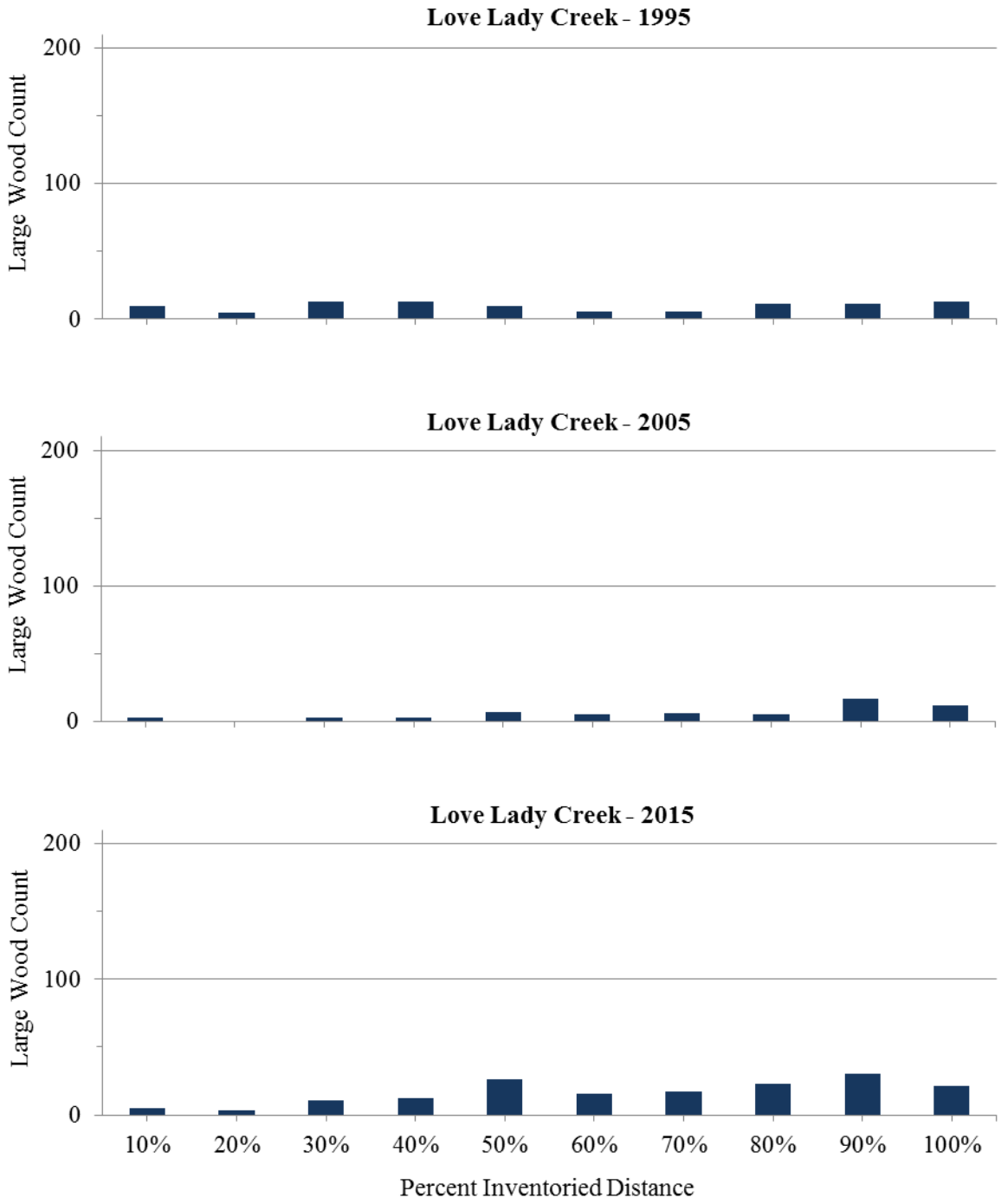


Figure D10. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Love Lady Creek. 1995 LW n=98 and habitat unit n=126, 2005 LW n=61 and habitat unit n=102, and 2015 LW n=164 and habitat unit n=104.

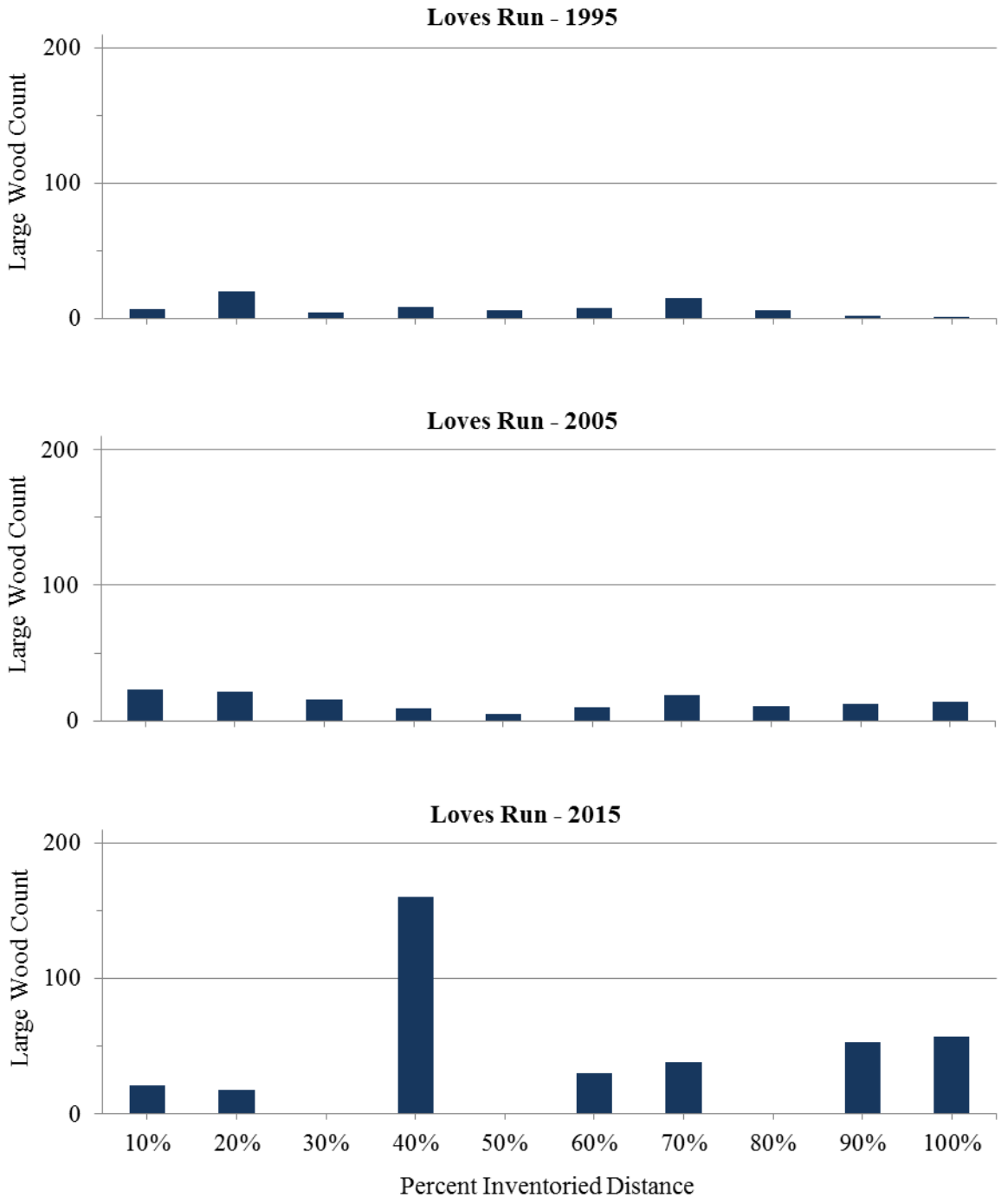


Figure D11. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Loves Run. 1995 LW n=79 and habitat unit n=243, 2005 LW n=140 and habitat unit n=91, and 2015 LW n=378 and habitat unit n=27.

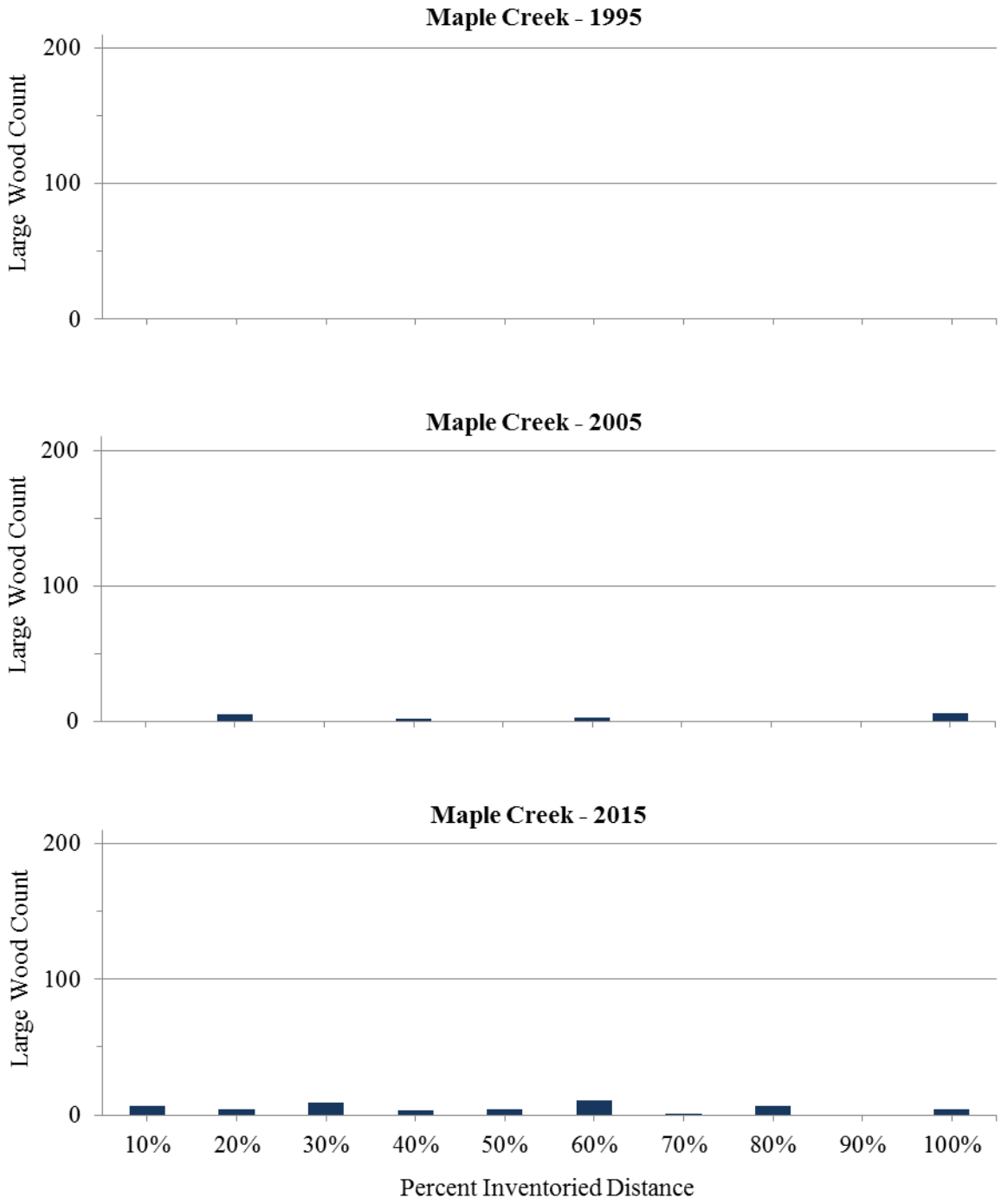


Figure D12. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Maple Creek (no LW data collected in 1995). 2005 LW n=16 and habitat unit n=11, and 2015 LW n=50 and habitat unit n=43.

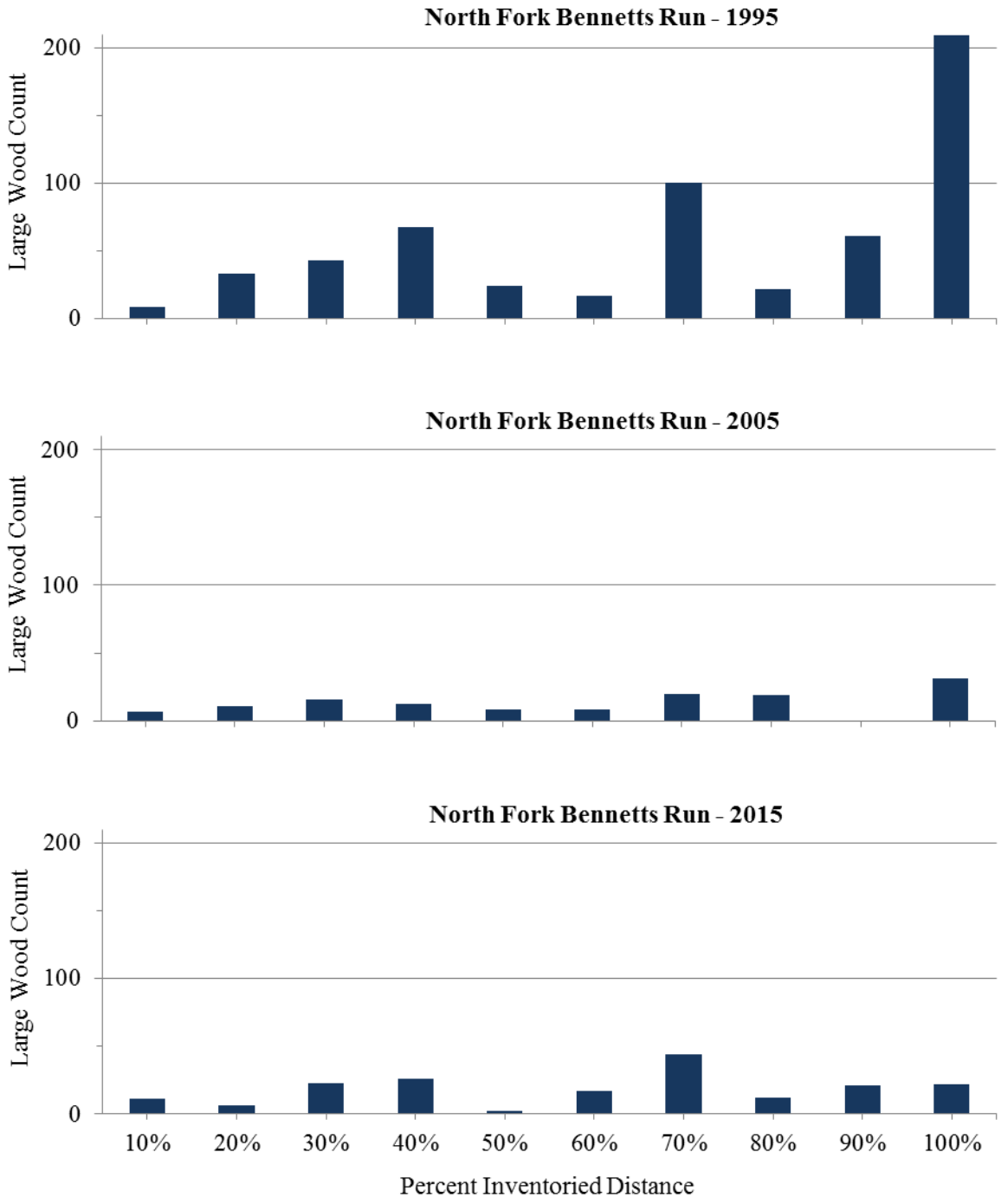


Figure D13. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in North Fork Bennetts Run. 1995 LW n=586 and habitat unit n=220, 2005 LW n=132 and habitat unit n=88, and 2015 LW n=184 and habitat unit n=58.

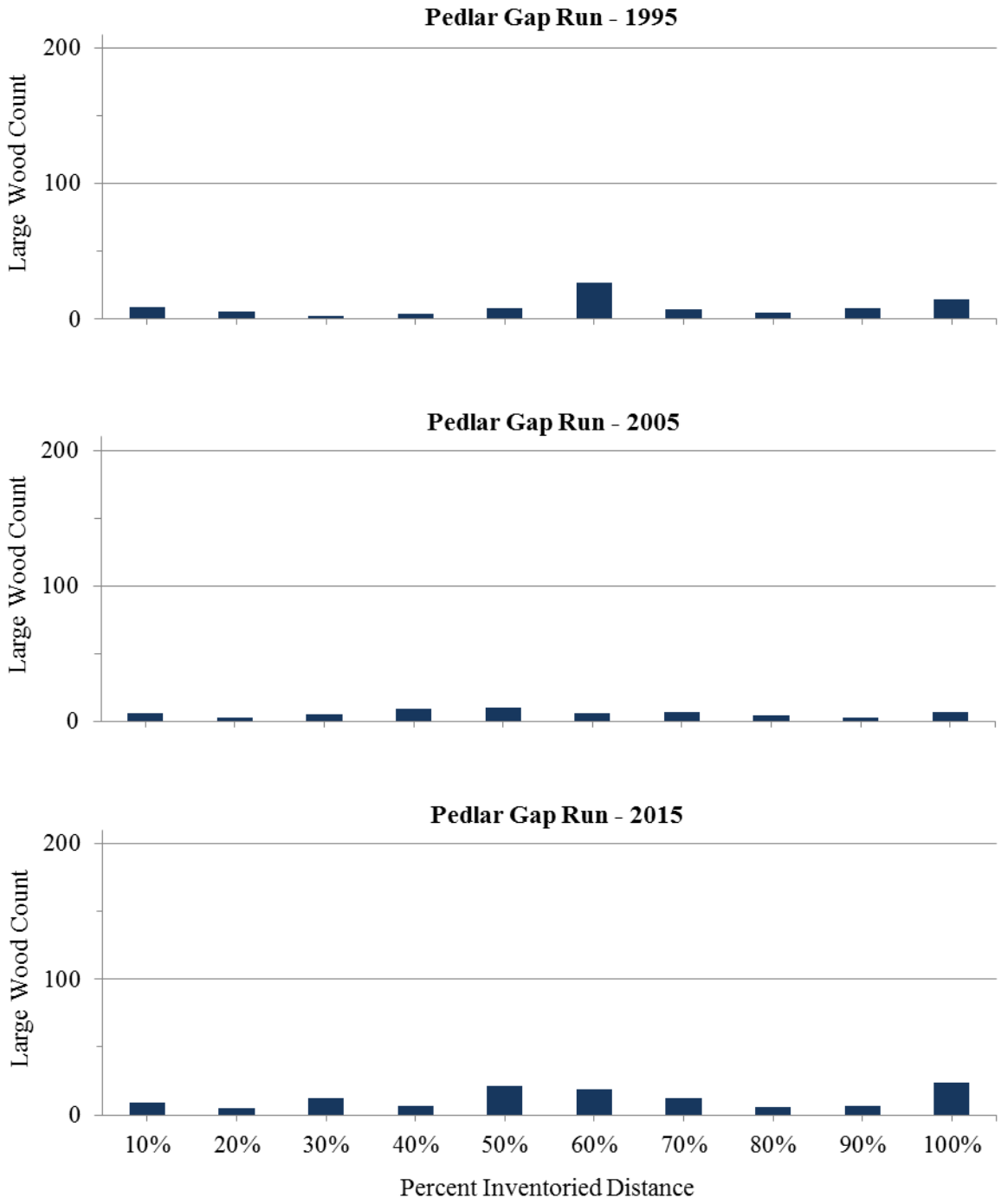


Figure D14. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Pedlar Gap Run. 1995 LW n=91 and habitat unit n=250, 2005 LW n=60 and habitat unit n=93, and 2015 LW n=122 and habitat unit n=81.

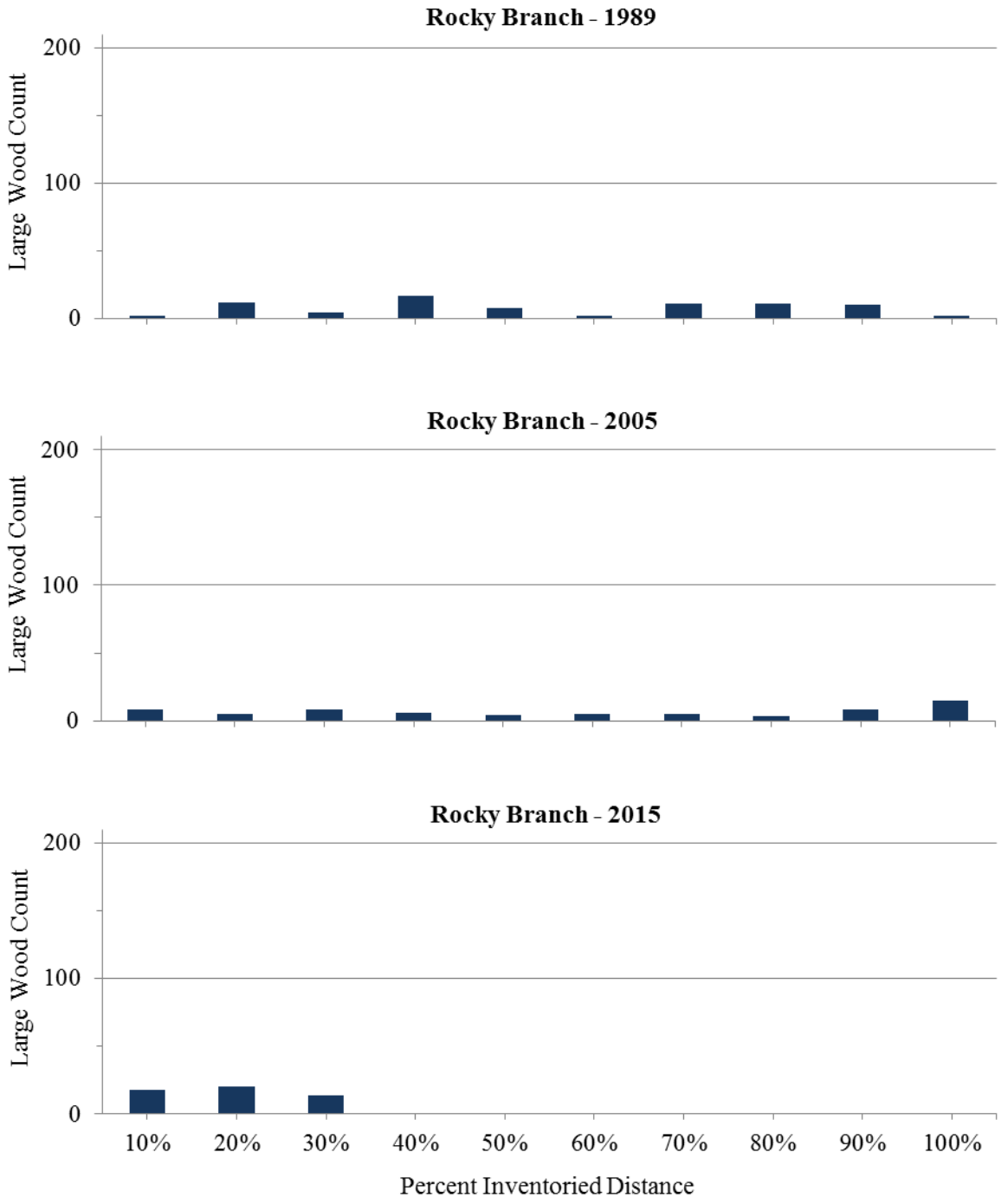


Figure D15. Count of large wood (bars = size classes 1, 2, 3, and 4 combined) within 10 equal length reaches (includes all habitat types: pool, glide, riffle, run, and cascade) in Rocky Branch. 1995 LW n=80 and habitat unit n=144, 2005 LW n=67 and habitat unit n=86, and 2015 (only 300 m inventoried) LW n=52 and habitat unit n=17.